PUBLISHED EVERY SATURDAY BY

THE W. J. JOHNSTON COMPANY, Limited,

167-177 TIMES BUILDING, NEW YORK.

Established 1874. Incorporated 1889.

Telephone Call: Cortlandt 924. Cable Address: "Electrical," New York.

New England Office, Room 28, Hathaway Building, 620 Atlantic Ave., Boston.
Western Office, 465 The Rookery, Chicago.
Philadelphia Office, 927 Chestnut Street.

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VOL. XVII. NEW YORK, APRIL 25, 1891. No. 17

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Tables of Wire Gauges. WE publish this week a valuable compilation by Mr. Carl Hering giving the diameters and cross-sections of all wires now in use. It is sometimes very desirable to be able to find readily the most economical size of wire for any case of transmission of current. Sometimes the conditions require the use of a size that falls between the regular numbers of our usual gauge, and then it becomes necessary either to take a size larger or smaller than was intended, or find the appropriate cross-section in some other wire gauge. As the British standard gauge is generally available in this country, the latter expedient is usually possible. Mr. Hering's table will be found very convenient in thus picking out proper sizes of wire, as it gives consecutively, according to size, all the wires of all the gauges employed to any extent. It is from advance sheets of a compact and useful little book on the computation of wiring that Mr. Hering is soon to bring out.

Economy in Incandescent Lighting. IN another column we give a thoughtful paper by Mr. T. G. Grier on the modern incandescent lamp, and its relation to lighting economy. It almost goes without saying that the method of operation most economical of lamps will not be most economical in total cost, for when a lamp is so run as to secure unusually long life it is at the expense of efficiency. The data on the subject up to the present time have been of the most empirical character, derived mainly from disjointed tests, so that the results have been for the most part rather shrewd guesses at the actual economy than exact measurements. Mr. Grier has done a good work in collecting and collating many of the facts, and putting them in a form where they can be intelligently studied. His tables are well worth the attention of central station managers, because, although the conditions as to cost of current and cost of lamps change widely from place to place, they are nearly constant for any one station, and their respective values can be so tabulated as to show the best relation between lamp life and lamp efficiency for any particular case.

The Telegraph and the Telephone. At the recent Patent Centenary Prof. Thomas Gray's account of the inventors of the telegraph and the telephone, given elsewhere in these pages, was received with the greatest interest. The facts as to the early history of these instruments are in a general way widely known, and yet very few persons have any distinct idea in detail of the progress of the successive inventions that lead up to both. It is most extraordinary to notice the ingenuity that was wasted and the progress that was made in attempts to telegraph by means of frictional electricity. When the electromagnet was invented telegraphy took a fresh start; its importance had been recognized for more than half a century, but the means were not at hand. The principle of the telegraph cannot with certainty be ascribed to any one man, but the honor of having devised the first practical working form will doubtless always be accorded to Professor Morse. As regards the telephone, Professor Gray's remarks are all too brief. Like the telegraph, the invention of the telephone had been in the air for many a year before the first working instrument was constructed. Means for transmitting articulate speech electrically had been sought, but were sought in vain, until the problem was attacked by one who through long years of study had made himself thoroughly familiar with the mechanism of human speech. Philip Reis had stumbled on the correct construction ten years before the discovery of Bell; Reis's telephone undoubtedly did transmit speech, but Bell's was deliberately designed for that purpose. Of the various inventors in the struggle the prize fell to the one whose previous training had given him the most complete grasp of the conditions to be fulfilled; and whatever may be said of the claims of others, or of the rapacity that has characterized the commercial applications of the telephone, this fact should be placed to the credit of the distinguished inventor.

Davenport's Early Correspondence. ON another page will be found a group of four letters, written about half a century ago by Thomas Davenport to his friend and patron, the Hon. Elijah Paine, of New York. They contain much that is of interest with regard to the early history of the electric motor, and admirably show the difficulties with which the inventors had to contend, as well as their really great ingenuity. It is somewhat surprising to note their experiments on the horseshoe form of magnet, but at that time news was very slow in being disseminated, and living, as Davenport did, in a rather out-of-the-way portion of the country, he was hardly to be expected to have informed himself regarding the progress that had already been made. His keenness as an observer is well illustrated by his noticing that a difference in the grain of the metal produced an effect on the operation of a battery. His device for employing the momentum of the armatures in his early motors was really exceedingly ingenious, and the progress that he made showed the active nature of his inventive genius. Conservative, too, he was anxious to make a thoroughly successful motor before he began to sell stock. Some so-called electricians of the present day might well profit by his example. In the third letter of the series it is curious to note how Davenport was stumbling on the facts regarding change in permeability with increase of magnetizing force. But, perhaps, the most interesting bit of history contained in these letters is that to be found in the last, bearing date of 1847, where Davenport proposes to bring suit against the telegraph companies for infringing his patent, inasmuch as his claim called, broadly, for the application of magnetic and electromagnetic power as a moving principle of machinery and the telegraph instrument, of course, was so to be classed. The Davenport patent is the most remarkable example of the admission of a sweeping claim to be found in the history of the Patent Office, not even excepting the Bell telephone patent. But, less fortunate than Graham Bell, Davenport could not command the influence or the money to enforce the rights that had undoubtedly been given him, whatever the real merits of such an all-inclusive claim might be.

Electricity in Warfare. ON another page we give a somewhat extended account of the present development of the Sims-Edison torpedo, which may be considered typical of the modern dirigible and automobile submarine mines. The automobile torpedo has been in use for fifteen years, or thereabouts, but its sphere of action is somewhat limited, and as a weapon of precision it is anything but a success. In the few cases in which it has been tried in actual warfare its success has been limited. Its latest employment in the Chilian rebellion only resulted in blowing up a drydock more useful to the attackers than the attacked, instead of sinking the vessel against which it was aimed. With a torpedo like the Sims-Edison the case is widely different, for its progress can be marked, and it can be deliberately directed against a hostile vessel with every chance of doing its work effectively. Its onslaught cannot be dodged, for its speed is far greater than that practicable for a heavy iron-clad in hostile waters, and it has besides the power of doubling on its track if it perchance overshoots the mark, and following up its victim until destruction is assured. It is indeed hard to see how a systematic attack by dirigible torpedoes could fail of its purpose if properly supported by fire from revolving cannon and machine guns. Almost the only chance to cripple the attacking torpedo would be by a counter-attack by a torpedo-boat at very short range, and, while the latter craft can be easily disabled by rapid-fire guns, the torpedo cannot be crippled by anything short of a complete demolition of its float and signals by heavy shot. A dozen such weapons supplemented by stationary mines could close the ship channels all about New York against the possibility of successful attack. The Sims-Edison is not the only torpedo of this type, but it is perhaps the best known of all, and is an excellent example of the adaptation of modern science to serve the purposes of warfare. It must not be forgotten that the moral effect of the dirigible torpedo is something appalling. To be attacked by a fierce shore fire against which all guns can be at once turned with the advantage on the side of the ship is one thing, but to be hunted down by an almost unseen foe bearing a quarter of a ton of dynamite is little short of demoralizing. Few commanders would have the nerve deliberately to attempt forcing a passage through a channel known to be defended by such terrific weapons.

The Telephone Monopoly. OUR London correspondent gives some notice this week of the state of the telephone facilities in London. Although the principal patents have expired and the field is thrown open to competition, the results have not been altogether satisfactory thus far. There has been a most substantial reduction in rates, but long years of monopoly have given the telephone companies such a deadly grip on the public that they are not easy to shake off. However, since the telephone business is practically open to all comers public opinion and active opposition will soon bring the telephone magnates to terms. Here, however, we may not be as fortunate. At various times during the last year attention has been called to the machinations of the Bell Telephone Company and its attempts to retain its monopoly after its legal end in 1893. A few weeks since we reviewed the present state of the telephone patents, and showed there was at least one possibility for the granting of a patent on transmitters to the Bell Telephone Company through applications made years ago, and kept in interference with, presumably, fraudulent intent. Inasmuch as the Bell Telephone Company now owns the vast majority of the early patents, and applications for patents, it has an opportunity for perpetrating just this outrage on the public. Recently the daily press has exposed the Berliner-Edison interference, covering in its broadest form the microphone transmitter. The interferences mentioned are not the only ones available for the Bell company, if it desires to employ them, and that such is its intention can hardly be doubted. In other words it has been deliberately keeping alive conflicting claims, all of which it owns, for the purpose of securing the issue of a patent dated the full term of a patent later than the invention and many years after the inventors have ceased to have any rights in the matter, by the transference of their individual claims to the gigantic monopoly that now proposes to utilize them for its own extortionate purposes. It is high time for our patent law to be so reformed as to render such manœuvres impossible. As it is the long-suffering public has two means of defense; one is to bring such a tremendous pressure upon the Commissioner of Patents that he will not dare to grant a palpably unjust patent in the face of such dangerous opposition—the other possibility is to overthrow all the American litigants by opposing to their somewhat doubtful rights the early use of the microphone abroad. It is hard to say so long before the actual trial how successful this latter move would be, but we were treated not long ago to an exhibition of prolonging interferences that came to grief in exactly this way. The case involved the laminated armature, without which the modern dynamo and motor is impracticable. Litigation in the patent office between two alleged inventors was carried on for nearly a decade; the patent was finally issued to one, who instantly licensed the other. Just at this juncture the foreign electrical press were unkind enough to point out the fact that nearly twenty years ago the laminated armature had been described in one of the scientific journals of the day, and laminated armature machines had been constructed. The interference in this case may have been in perfectly good faith, but it availed nothing, and no serious attempts to enforce the resulting patent are on record. It is possible that the Bell Telephone Company may find its carefully considered efforts to enslave the public for another seventeen years will be rendered futile in a similar fashion.

Latest Foreign Electrical News.

(By Cable from our Regular Correspondent.)

London, April 20, 1891.—An interesting paper by Dr. J. A. Fleming, on the so-called Ferranti effect, will be read before the Institution of Electrical Engineers at an early date.

The very unsatisfactory state of the London telephone service has resulted in the formation of a subscribers' association for the purpose of securing better service and more satisfactory rates. In this connection there is some possibility of the Post-office running a telephone exchange of its own. The London-Paris telephone line now transmits about fifty conversations per day. Since the rates for a three-minute conversation are $2, the lowest possible revenue of the company is $100 per day, and it is fair to assume that many customers exceed the three-minute limit, and thus raise the average toll per message.

The traffic on the City & South London Railway has settled down to a steady average, and about 100,000 passengers are now carried weekly. The operation of the road continues to be entirely satisfactory. Since the fare charged per passenger is about four cents, it will be seen that the daily income from the traffic is not far from $6,000.

NEW BOOK.

Hints to Power Users. By Robert Grimshaw, M. E. Pp. 160. New York. Cassell Publishing Company, 1891.

This little volume justly claims to contain plain practical pointers for the man who pays the bills. It is just such a popular account of engines and boilers as will frequently save no small amount of money for intending purchasers. Handbooks for engineers are common enough, but a handbook for those who desire to procure equipment for small factories and the like is something unique. The author has succeeded in packing into a brief space a very large amount of valuable information, and many exceedingly practical and level-headed suggestions. In addition to the discussion of steam engines and boilers, useful hints are added regarding gas engines, hot-air engines, water wheels and electric motors. These subjects are, of course, treated less fully than the steam engine, but with the same practical common-sense directness. Perhaps a more extended notice of the conditions under which water power is advantageous would have been advisable in connection with some hints on the long-distance transmission of electrical power. Altogether the book is one that meets a real want, and should make itself popular among those for whose information it was particularly designed.

Moonlight Tables for May, 1891.

Herewith we give Mr. H. W. Frund's table of lighting hours for the month of May, under his modified form of moon schedule.

TABLE NO. 1.
Standard Moonlight.
Philadelphia System.

Date.	Light.	Date.	Extinguish
1	7:25 P.M.	2	3:10 A.M.
2	7:25	3	3:45
3	7:25	4	3:55
4	7:25	5	3:55
5	7:30	6	3:55
6	7:30	7	3:55
7	7:30	8	3:50
8	7:30	9	3:50
9	7:30	10	3:50
10	7:35	11	3:50
11	7:35	12	3:50
12	7:35	13	3:45
13	11:35	14	3:45
14			
15	12:10 A.M.	15	3:45
16	12:40	16	3:45
17	1:05	17	3:45
18	1:30	18	3:40
19	1:50	19	8:40
20	2:10	20	3:40
21	2:35	21	3:40
22	No light.	22	No light.
23	No light.	23	No light.
24	No light.	24	No light.
25	7:45 P.M.	25	10:40 P.M.
26	7:45	26	11:35
27	7:50	28	12:30 A.M.
28	7:50	29	1:10
29	7:50	30	1:45
30	7:50	31	2:20
31	7:50	1	2:45

Total hours lighting, 155.45.

TABLE NO. 2.
Frund's New Moonlight System.

Date.	Light.	Date.	Exting.
1	7:25 P.M.	2	3:10 A.M.
2	7:25	3	3:45
3	7:25	4	3:55
4	7:25	5	3:55
5	7:30	6	3:55
6	7:30	7	3:55
7	7:30	8	3:50
8	7:30	9	3:50
9	7:30	10	3:50
10	7:35	11	3:50
11	7:35	12	3:50
12	7:35	13	3:45
13	7:35	14	3:45
14	7:40	15	3:45
15	7:40	15	12:00 M.
16	12:40 A.M.	16	3:45 A.M.
16	7:40 P.M.	16	12:00 M.
17	1:05 A.M.	17	3:45 A.M.
17	7:40 P.M.	17	12:00 M.
18	1:30 A.M.	18	3:40 A.M.
18	7:40 P.M.	18	12:00 M.
19	1:50 A.M.	19	3:40 A.M.
19	7:45 P.M.	19	12:00 M.
20	7:45	20	12:00
21	7:45	21	12:00
22	7:45	22	12:00
23	7:45	23	12:00
24	7:45	24	12:00
25	7:45	25	12:00
26	7:45	26	12:00
27	7:50	28	12:30 A.M.
28	7:50	29	1:10
29	7:50	30	1:45
30	7:50	31	2:20
31	7:50	1	2:45

Total hours lighting, 206.25.

Phenomena of Alternating Currents of Very High Frequency.

BY ELIHU THOMSON.

It is not from any desire to have the last word that I have answered Mr. Tesla's statements as they appeared * It has simply been to correct misunderstandings. In regard to the experiment which I mentioned as performed by immersing in water a lamp bulb in which a single strip of carbon had been mounted, and connecting the water and the filament to a source of high potential alternating current at high frequencies, and whereby the strip of carbon was brought to bright incandescence, I simply said that conduction through the glass could not have had any effect in this experiment. I made no general denial that a slight conduction occurred with even the best dielectrics. The glass in my experiment being immersed in water, the assumption of high temperature which Mr. Tesla makes, as increasing the conductivity of the glass, is not to be considered in this case. The glass was only heated where it was not so immersed, and where, therefore, no connection with the circuit existed.

Mr. Tesla bases a long statement about dielectrics, insulation resistance, perfect conductors, degrees of conductivity, etc., on the statement I made in relation to the experiment and the phenomenon it presented; and he even asks whether I have "then never measured insulation resistance" and "by a conduction current." Similar irrelevant questions follow this typical one. I had said that "if conduction through the glass were a possibility" (in the experiment and accounted for the phenomenon presented) "this action" (of charging a lamp bulb as a Leyden jar and receiving a charge therefrom) "could not occur." Mr. Tesla does me the injustice of applying a statement, which related to a particular experiment and phenomenon, to classes and conditions of phenomena which any one at all familiar with the circumstances would rule out. Mr. Tesla says: "My statement that conduction is concerned to some, *though perhaps negligible*, extent in the experiment above described was, however, made not only on account of the fact that all bodies conduct more or less, but principally on account of the *heating of the glass* during the experiment." The italics are mine. In the experiment the glass was immersed in cold water and only that portion not immersed and not in contact with the current conductor or the surrounding water was warmed. This disposes of the paragraph of contentions of Mr. Tesla based on heated glass in the experiment.

In regard to the estimate of the number of complete waves of sound corresponding to a given number of alternations, I freely confess that I was in error, and that the number given by Mr. Tesla is correct. The number of complete sound waves does, as Mr. Tesla points out, correspond to the number of alternations, as the expansion and the contraction of the arc stream corresponding to wave condensation and rarefaction occur with each alternation. This is a point which I had missed in the former consideration of the matter, but, of course, if the limit of audition is above any of the rates considered, it would not affect the argument except as it relates to the degree of approximation to that limit.

Without calling upon Mr. Tesla to state how far "earth is from heaven" in his view, I will simply state that my experiment of five or six years ago, which called forth his remark, certainly did teach me something then, and added somewhat to my information in certain directions.

I was perfectly well aware of the effects of self-induction, including impedance, pointed out by Mr. Tesla, when I spoke of the insertion of a coil of large self-induction into a circuit of arc lights as steadying the current and lessening its undulations. In regard to the effects of self-induction, I may state that the property of impedance I have always regarded as one of those effects. It is not true, as stated by Mr. Tesla, that self-induction "renders the undulations more pronounced." Whether it will do so or not depends on the shape of the wave of undulation. Not all shapes of wave have the greatest rate of change when the current has a small value. What is true in this respect of a sine curve would not be true of a saw-tooth wave. But the point under discussion originally was the effect of a large self-induction interposed in a circuit of arc lights in which the current was of a fluctuating character. The current may be considered in this case as made up of a steady current of an average current value, upon which has been superimposed an alternating current of small value, or it may be considered as made up of a steady current of less than the average value with a pulsating current of small value superimposed. These assumptions to be exact, of course, are made on the basis that in the fluctuations the strength of the current does not change very greatly, or that the minimum current and the maximum current values are not far removed from the average value.

Now, the effect of self-induction introduced into such a circuit with arc lights is, by its impedance, to diminish the value of that portion of the current which is, so to speak, alternating or fluctuating, and whether the waves of alternating or pulsating currents, so greatly diminished in amplitude, will be sharpened or smoothed out by self-induction will depend upon their original form. It is the effect of self-induction in producing impedance, and, therefore, restricting the value of the fluctuating or alternating current strength, superimposed on the much larger constant or steady current, to which I referred in speaking of the smoothing action. Mr. Tesla was right in his general statements of principle, but wrong in his application of them to the case in point. He was not right, however, in separating the effect of impedance from self-induction in the case under discussion.

I have no desire to prolong this discussion, and will leave out of consideration any reference to effects on clutch or clockwork lamps, or to the physiological effects of currents. I have in the above comments confined myself strictly to those matters which it seemed necessary to have cleared up in some way. I hope that, in stating my position in relation to the matter, I have made myself clear so as to avoid further misunderstandings.

* See The Electrical World, April 11, 1891.

Variations of Current in Primary Conductors of Open Circuit Transformers.

BY ROBERT SHAND.

It is well known that a claim for high efficiency has been made on behalf of the Ruhmkorff variety of the open magnetic circuit type of transformer. The principal objections raised against its use are the large amount of copper used in its construction and the large primary magnetizing current required. If such a transformer be run with its secondary conductor open circuited, or closed and carrying its maximum load, the current passing in the primary conductor will not vary between wide limits.

It has for a long time been equally well known that, if the magnetic circuit, or induction path, be closed through iron, the magnetizing current is reduced to a relatively small value, and the secondary circuit being closed the currents in the conductors—primary and secondary—will rise and fall together, maintaining a nearly constant ratio for all values of the secondary load; also that by using a large quantity of iron a small quantity of copper could be used in their construction.

Apparently, considerations of this nature, coupled with its assumed high efficiency, assisted to establish the closed type in popular favor and enabled it quickly to supersede the Ruhmkorff variety of transformer in practical applications. However, the gradual accumulation of easily applied data touching the behavior of iron when subjected to magnetizing forces suggested to engineers engaged in the design of transformers modifications of such design calculated to increase the efficiency of the transformer.

To effect this improvement required that the iron used in their construction be reduced in volume, and, it being necessary to avoid the excessive absorption of power (and also magnetic leakage) incidental to a high induction, the induction per unit of core section could not be materially increased. More turns of the copper conductor were, therefore, made necessary, and their consequent increase of length required that the section be increased also in order to have the quantity $C\,R$ of moderate dimensions.

To accommodate the increased volume of copper more wire space becomes necessary, and, as providing it requires that something of the increment in efficiency aimed at be foregone, a temptation arises, even in the case of the ordinary commercial closed circuit transformer, to torture the insulation by squeezing the coils into holes in the iron too small to properly receive them.

It will be observed that the development of the transformer to a point of high efficiency has been accomplished largely by the removal of iron and the addition of copper, and to the extent that this is done does the modern closed magnetic circuit transformer decrease the distance separating it from the Ruhmkorff variety of the open type in the ratio existing between the quantities of the two materials, copper and iron, entering into its construction. The desire to substitute copper for iron would thus appear to lead designers quite easily and naturally, as it were, back to the open type, in order to find room for the copper and secure the efficiency accompanying its use.

There remains to be considered the large magnetizing current. Mr. Swinburne, who appears early to have grasped the conditions governing the general efficiency of the transformer, and who, in preaching the gospel of his particular "ism" has undoubtedly done much toward disseminating a knowledge of said conditions, set himself the task of reducing this large magnetizing current to moderate dimensions, apparently believing that if this could be done a practical form of apparatus would be secured, having at light load an efficiency superior to that yielded by the modern closed type. His labors resulted in the production of a compromise—a kind of connecting link—which he dubbed "hedgehog," and for which he claimed, in addition to high efficiency, that the peculiar method of construction followed resulted in a material reduction in the value of the magnetizing current required. Mr. Stanley, on the other hand, discussing this subject in his article on "Plant Efficiency" made no distinction as between the "hedgehog" and other varieties of the open type.

Both gentlemen are familiar with transformer phenomena, and expressions of opinion from them receive wide attention. As, however, they differed on this point it was thought the article,* by replying to which Mr. Stanley honors the writer, would incidentally serve to clear up the misunderstanding somewhat, inasmuch as the results there shown indicated the variety of the type to which his statement applied and also the variety to which it did not apply, and as the latter, though much written about, was not well known, fair play demanded that its merits, whatever they were, be carefully considered before judgment regarding it be promulgated.

Mr. Stanley raises the objection that the transformer on which the observations were made was not comparable with standard commercial apparatus, the permissible drop in which he claims is 1.5 per cent.

It is true, as pointed out by the writer in the article referred to, the apparatus used was of an experimental character, and is consequently to be regarded only as an approximation to the apparatus which would be put forward to compete with highly developed representatives of the modern closed type. It may be observed, however, that the efficiency obtained was comparable with that yielded by

* See The Electrical World, March 21 and April 4, 1891.

the latter, and that the efficiency as well as the regulation could be much improved by following well-known methods. It may also be pointed out that the drop observed was greater than the calculated drop. This was undoubtedly due to magnetic leakage, causing independent back electromotive forces on the coils; this, however, ought to be largely reduced by suitable disposition of the coils.

Electric Lighting Plant at Gardner, Mass.

Gardner is 65 miles west from Boston on the Fitchburg Railroad. The station of the Gardner Electric Company is finely located on the shore of a lake, from which water is obtained to supply the boilers and condensers. The company began business in October, 1888, with one boiler, one 75 h. p. engine, one 50-light arc and one 500-light incandescent dynamo. Since the acceptance of the plant from the parent company it has been under the management of Mr. Eugene F. Carpenter, and, in spite of active opposition by the gas company and the fact that the town has only about 8,000 inhabitants, the business has grown to 90 arc and 2,200 incandescent lights.

Current for incandescent lighting is sold by meter and the arc lighting and motor business is done by contract. There is probably as much house incandescent lighting done in Gardner as in any other town of the same size. One consumer says that what he has saved in doctors' bills since introducing the light at his house two years ago will pay his lighting bills.

The station equipment now consists of two horizontal, tubular, steel boilers, with shells 5 × 15 feet, each having 80 three-inch tubes and each run at a working pressure of 100 pounds; one 11 × 24 "Fitchburg" condensing engine, which makes 150 revolutions per minute, and a cross-compound condensing engine, of the same company's make, with cylinders 12 and 22 × 24 inches, which makes 134 revolutions per minute. Cards have been taken from these engines aggregating 279 h. p.

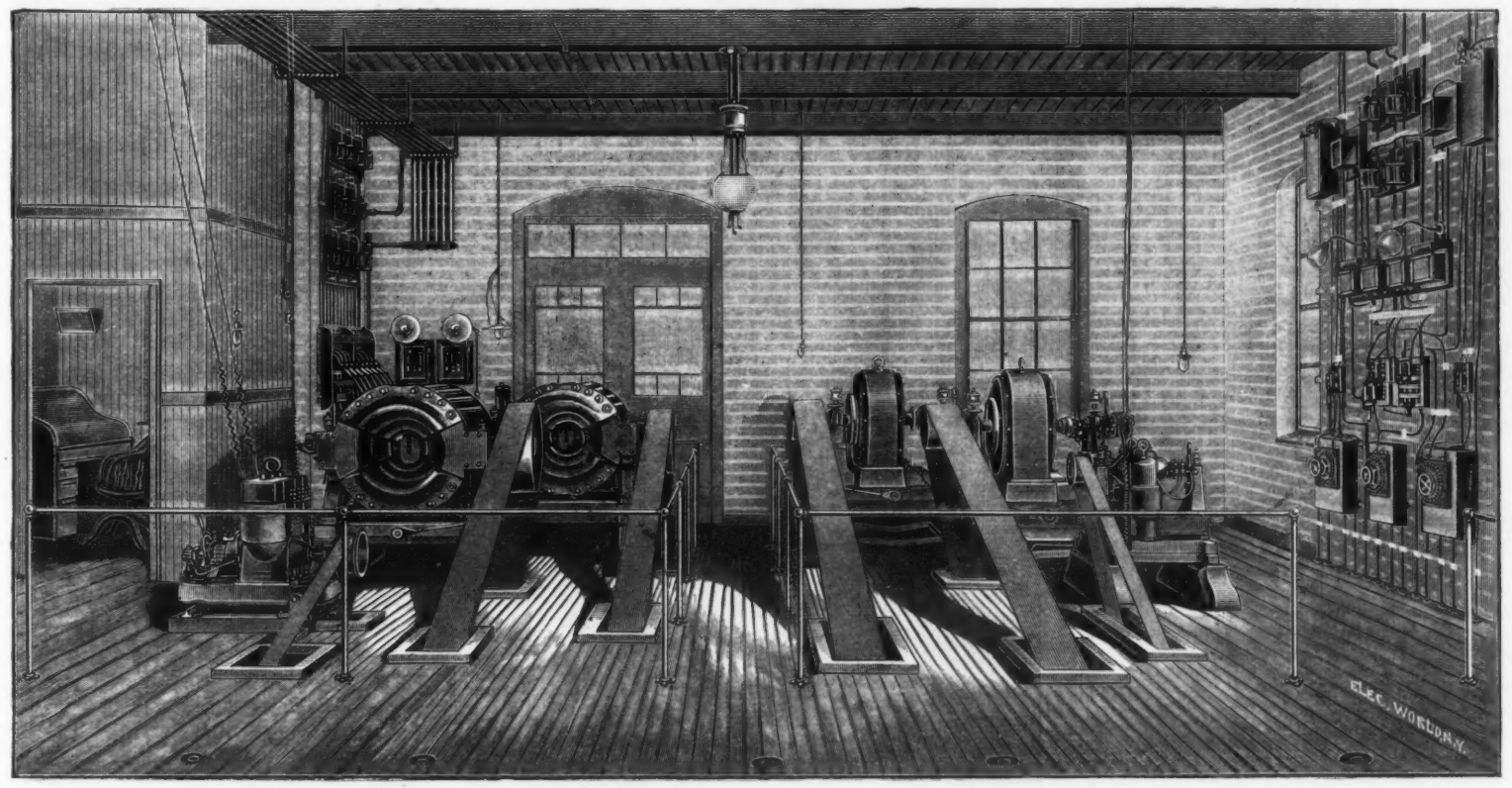
The pipes from the boilers to the engines, condensers, injectors, feed and fire pump are covered with magnesia sectional covering. There is scarcely any loss by condensation in the pipes. The feed water has a temperature of only 160 degrees Fahrenheit, but the engines develop a horse power on about three pounds of coal per hour. The power is transmitted to the dynamo by means of a four and a half inch shaft located in a room below the main floor, in which are also located the two Deane condensers. The shaft is in three parts—a short piece at each end, connected by belt to its engine, and a long piece in the middle carrying the clutch pulleys from which the dynamos are driven. Hill clutches are used throughout, and are giving excellent satisfaction. The belts used were made by H. O. Hudson & Co., Worcester; Henry C. Hunt & Co., Boston, and the Underwood Manufacturing Company.

The dynamos, as shown in the illustration on this page, consist of two Thomson-Houston alternating current machines with exciter, which together will run 1,300 lights; two Thomson-Houston machines with a capacity of 100 arc lamps of 300 watts each, and a small Edison 500-volt machine for motor service. The switchboards are somewhat novel. They are of wood, covered with fire-proof paint. The apparatus and wires are supported on porcelain insulators, there being a ¾-inch space between the wires and the board, the rheostats, switches, instruments and lightning arresters being removed about 1¼ inches. The lightning arresters are at the top of the boards, in plain view from any part of the room.

The station is lighted by both arcs and incandescents. The advantage claimed in having the two switchboards apart is that, should a fire start on the arc board, the arc machines would be immediately shut down, and the attendant would have the incandescent lights to aid him in extinguishing the flames, or vice versa. A fire pump in the boiler room, connected to some hose on a rack in the centre of the building, gives very good protection.

The lines are well built, poles are of cedar and chestnut, 30 and 40 feet in length, and the arms are braced. Simplex wire is used in all the line work, and is all that could be desired. Of this, 5,300 feet of No. 0, 16,250 feet of No. 4, 17,500 feet of No. 6 and 3,500 feet of No. 8 have been used in the two incandescent lighting circuits; 5,000 feet of No. 4 and 9,000 feet of No. 8 on the motor circuit; 15,500 feet of No. 6 on the two commercial arc circuits, and 92,000 feet of No. 6 on the two street circuits.

A simple system of daily reports, designed by the superintendent, has always been kept at this station. On it is recorded at stated times through the day the steam pressure, voltage, current, vacuum, back pressure and indicated horse power; times of starting and stopping each machine; lamps; carbons, oils, waste, coal, etc., consumed; times when engineer, assistant and linemen went on and off duty, and, in addition, each man is required to put in a time card stating what he has done and the number of hours worked. This report is figured up every day, and a diary appended describing events, goods received and their condition, goods shipped, and general outlines of trouble, if any. Each day this is copied into a book, making a very valuable reference. The original sheets are sent to the president of the company, who is thus kept well informed. An engineer, assistant engineer, trimmer, and boy to wipe machinery, constitute, with the superintendent, who is also the manager, the working force of the plant. Considering the fact that the dynamos are run all night, this is a very small force. With the exception of the breaking of a belt, which put out the incandescent lights one hour last year, there has been no shut down of the station. It would be difficult to find a much better arranged station, or one where the record is more complete and expenses much less for the size of the plant than at Gardner.



DYNAMO ROOM OF THE GARDNER (MASS.) ELECTRIC LIGHTING STATION.

Telephone Business in Mexico.

At the annual meeting of the Mexican Telephone Company the following facts were brought out: There are in the City of Mexico 759 subscribers, and elsewhere in its territory (location not stated) 364 subscribers (probably in the cities of Guadalajara and Puebla), making in all 1,123. The monthly rental is from $5 to $6 per month.

Referring to old reports of this company, it appears that in 1882 it had over 700 subscribers in the city of Mexico. In 1886 its report showed it had in the city of Mexico 671 subscribers, in Guadalajara 160, in Puebla 78, a total of 909, an increase of 144 for the year. The present report shows 1,123 subscribers, or an increase of 214 in four years.

A stockholder of this company says: "Considering the rapid growth of all business interests in Mexico, this is slow progress, and it shows, what has been repeatedly suggested, that the present company should be reorganized, and its capital materially reduced or merged with the subcompanies, and more working capital provided with which to extend the business in all the chief cities. In the territory of the Mexican Central Telegraph and Telephone Company there are 45 cities capable of supporting an exchange, 11 being in the State of Zacatecas, 12 in the State of San Luis Potosi, 12 in Guanajuata, 7 in Quecetaro, and 3 in Aguas Calientes.

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Chronological History of Electricity, Galvanism, Magnetism and the Telegraph, from B. C. 2637 to A. D. 1888.—Part I.*

BY P. F. MOTTELAY.

B. C. 600 to 580.——Thales, of Miletus, Ionia, one of the "seven wise men of Greece" (the others being Solon, Chilo, Pittacus, Bias, Cleobulus and Periander), founder of the Ionic philosophy, and from whose school came Socrates, is said to have been the first to observe the electricity developed by friction in amber.

Thales, Theophrastus and Pliny, as well as other writers, Greek and Roman, mention the fact that when a vivifying heat is applied to amber it will attract straws, dried leaves and other light bodies in the same way that a magnet attracts iron.

Boyle ("Philosophical Works," London, 1738, vol. I., p. 506, or London, 1744, vol. III., p. 647) treats of different hypotheses advanced to solve the phenomena of electrical attraction, saying: "The first is that of the learned Nicholas Cabæus (A. D. 1629), who thinks the drawing of light bodies by amber . . . is caused by the steams which issue out of such bodies and discuss and expel the neighboring air, . . . making small whirlwind. . . . Another is that of the eminent English philosopher, Sir Kenelm Digby, and 'embraced by the very learned Dr. Browne and others, who believed that . . . chafed amber is made to emit certain rays of unctuous steams, which, when they come to be a little cooled by the external air, are somewhat condensed, . . . carrying back with them those light bodies to which they happen to adhere at the time of their retraction.' . . . Pierre Gassendi (A. D. 1632) thinks the same, and adds 'that these electrical rays . . . get into the pores of a straw, . . . and by means of their decussation take the faster hold of it . . . when they shrink back to the amber whence they were emitted.' . . . Cartesius 'accounts for electrical attractions by the intervention of certain particles, shaped almost like small pieces of ribband, which he supposes to be formed of this subtile matter harbored in the pores or crevices of glass.'" See Becquerel, "Traité Expérimental," Paris, 1834, vol. I., p. 33; Pliny, "Natural History," Bostock & Riley, 1858, book 37, chap. 12, p. 403; Pline, "Histoire Naturelle," 1778, lib. 37, cap. 3; Lardner, "Lectures," p. 182; Poggendorf, XI., p. 1,088; Timæus, "The Locrian," "De Anima Mundi . . . " (Amber); Pauli (Adrian), Danzic, 1614; Aurifaber (Andreas), "Succini Historia, etc.," Königsberg, 1551–1561.

B. C. 600.——The Etruscans are known to have devoted themselves at this period to the study of electricity in an especial manner. They are said to have attracted lightning by shooting arrows of metal into clouds which threatened thunder. Pliny even asserts that they had a secret method of not only "drawing it (the lightning) down" from the clouds, but of afterward "turning it aside" in any desired direction. They recognized different sources of lightning, those coming from the sky (*a sideribus venientia*), which always struck obliquely, and others from the earth (*infera*, *terrena*), which rose perpendicularly. The Romans, on the other hand, recognized only two sorts, those of the day, attributed to Jupiter, and those of the night, attributed to *Summanus*.

Tradition says that Numa was initiated by the priests of the Etruscan divinities, and instructed by them in the secret of forcing Jupiter, the Thunderer, to descend upon earth. Salvarte believes that before Franklin discovered his refined electricity, Numa had experimented with it

* Continued from THE ELECTRICAL WORLD, April 18, 1891.

most successfully, and that Tullus Hostilius was the first victim of the dangerous "heavenly guest" recorded in history. Salvarte remarks that Pliny makes use of expressions which seem to indicate two distinct processes; the one obtained thunder (*impetrare*), the other forced it to lightning (*cogere*). Tracing back the knowledge of thunder and lightning possessed by the Etruscan priests, we find that Tarchon, the founder of the theurgism of the former, desiring to preserve his house from lightning, surrounded it by a hedge of the white bryony, a climbing plant which has the property of averting thunderbolts. The Temple of Juno had its roofs covered with numerous pointed blades of swords. Ben David, says the author of "Occult Sciences," has asserted that Moses (born about 1570 B. C.) possessed some knowledge of the phenomena of electricity. Prof. Hirt, of Berlin, is of this opinion. Michaelis remarks that there is no indication that lightning ever struck the Temple of Jerusalem during a thousand years: that, according to Josephus, a forest of points, of gold and very sharp, covered the roof of the temple, and that this roof communicated with the caverns in the hill by means of pipes in connection with the gilding which covered all the exterior of the building, in consequence of which the points would act as conductors. Salvarte further asserts that in the days of Ktesias, India was acquainted with the use of conductors of lightning. This historian plainly states that iron placed at the bottom of a fountain, and made in the form of a sword, with the point upward, possessed, as soon as it was thus fixed in the ground, the property of averting storms and lightning. See Mme. Blavatsky, "Isis Unveiled," 1877, vol. I., pp. 142, 457, 458, 527, 528, and her references to Ovid "Fast," lib. III., v. 285, 346; Titus Livius, lib. I., cap. 31; Pliny, "Hist. Nat.," lib. II., cap. 53, and lib. 28, cap. 2; Lucius, "Piso"; Columella, lib. 10, v. 346, etc.; La Boissière, "Notice sur les Travaux de l'Acad. du Gard," pt. I., pp. 304–314; "Bell. Jud. adv. Roman," lib. 5, cap. 14; "Magas. Sc. de Göttingen," 3e année, 5e cahier; Ktesias, in "India ap. Photum. Bibl. Cod.," 72. See also De La Rive, "Electricity," London, 1858, vol. III., chap. 2, p. 90; Eighth "Britannica," art. "Electricity;" Lardner, "Lectures," II., p. 99; "Cosmos," vol. II., 1849, p. 503.

B. C. 588.——The earliest reliable record of messages transmitted by the sign of fire is to be found in the book of Jeremiah, chap. 6, verse 1: "O ye children of Benjamin, gather yourselves to flee out of the midst of Jerusalem, and blow the trumpet in Tekoa, and set up a sign of fire in Beth-haccerem: for evil appeareth out of the north and great destruction." See Turnbull, "Electro-magnetic Telegraph," 1853, p. 17: Knight's "Mechanical Dictionary," vol. III., p. 2,092; Penny and other encyclopædias.

B. C. 341.——Aristotle, a Greek philosopher, says ("Hist. of Anim.," IX., 37) that the electrical torpedo "causes or produces a torpor upon those fishes it is about to seize, and, having by that means got them into its mouth, feeds upon them." The torpedo is likewise alluded to, notably by Plutarch, the celebrated Greek moralist (A. D. 66); by Dioscorides, Greek botanist (A. D. 150); by Galen, illustrious Roman physician (A. D. 172); and by Claudian, Latin poet (A. D. 395). Oppian describes (lib. II., v. 62) the organs by which the animal produces the above effect, and Pliny ("Nat. Hist.," lib. 32, cap. 1) says: "This fish, if touched by a rod or spear, at a distance paralyzes the strongest muscles, and binds and arrests the feet, however swift."

"The very crampe-fish, *tarped*, knoweth her owne force and power, and, being herselfe not benummed, is able to astonish others. (Holland, "Plinie," b. IX., c 42.)

"We here, and in no other place, met with that extraordinary fish called the torpedo, or numbing fish, which is in shape very like the fiddle-fish, and is not to be known from it but by a brown circular spot about the bigness of a crown piece near the centre of its back." Ausonius, "Voyages," b. 2, c. 12. See "Encycl. Metr.," IV., p. 41; "Britannica," art. Electricity; Fahie, "History of Electric Telegraphy," p. 170; *Sci. Am. Supp.*, No. 457, pp. 7,301, 7,302.

B. C. 341.——Æneas, the tactician, believed to be the same Æneas of Stymphale alluded to by Xenophon, invented a singular method of telegraphing phrases commonly used especially in war. These were written upon exactly similar oblong boards placed at the dispatching and receiving stations, where they stood upon floats in vessels of water. At a given signal, the water was allowed to flow out of the vessel at each station, and when the desired phrase on the board had reached the level of the vessel another signal was made so that the outflow could be stopped and the desired signal read at the receiving station. See Laurencin, "Le Télégraphe," chap. 1; "Penny Cycl.," vol. 24., p. 145.

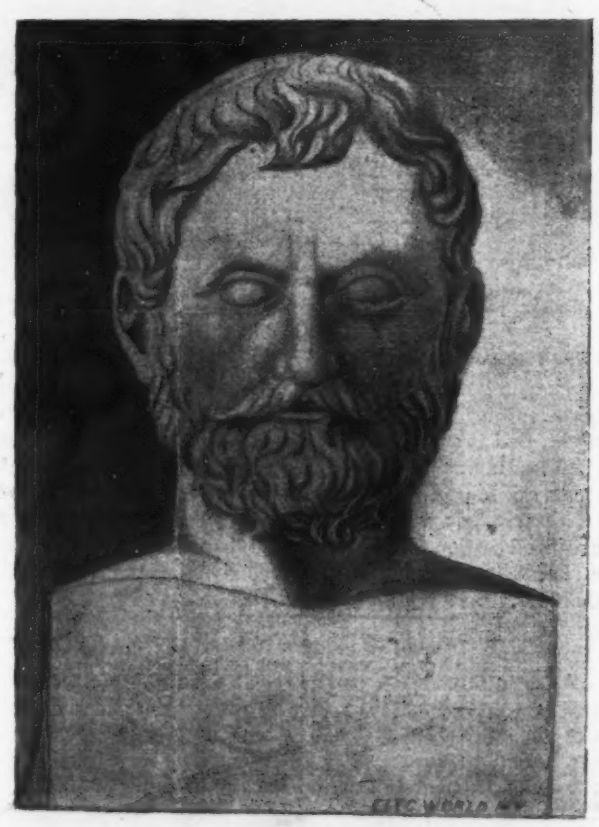
B. C. 337–30.——From the late work of Mme. Hélène Petrovna Blavatsky, the following is extracted regarding the modern "discoveries of Edison's force and Bell's telephone." Only in connection with these *discoveries* we may perhaps well remind our readers of the many hints to be found in the ancient histories as to a certain secret in the possession of the Egyptian priesthood, who could instantly communicate, during the celebration of the mysteries, from one temple to another, even though the former were at Thebes and the latter at the other end of the country; the legends attributing it, as a matter of course, to the "invisible tribes" of the air which carry messages for mortals. The author of "Pre-Adamite Man" quotes an instance, which, being merely given on his own authority, and he seeming uncertain whether the story comes from Macrinus or some other writer, may be taken for what it is worth. He found good evidence, he says, during his stay in Egypt, that one of the Cleopatras (B. C. 337–30) sent news by a wire to all of the cities from Heliopolis (the magnificent chief seat of sun-worship) to the island of Elephantine,

Aristotle.

on the upper Nile. See Blavatsky, "Isis Unveiled," vol. I., p. 127; P. B. Randolph, "Pre-Adamite Man," p. 48.

B. C. 321.——Theophrastus, Greek philosopher, first observed the attractive power of the *lyncurium*, supposed by many to be the *tourmaline*, and gave a description of it in his treatise upon stones ("De Lapidus," sec. 53, or the translation of Sir John Hill in 1774). This crystal was termed *lapis lyncurius* by Pliny, in his "Nat. Hist.," and *lapis electricus* by Linnæus, in his "Flora Zeylonica."

Theophrastus and Pliny speak of this native magnet as possessing, like amber, the property of attracting straws, dried leaves, bark and other light bodies. The different



Thales.

kinds of loadstone are thus alluded to by Pliny ("Nat. Hist.," lib. 36, cap. 16): "Sotacus describes five kinds, the Æthiopian; that of Magnesia, a country which borders on Macedonia; a third from Hyettus, in Boetia; a fourth from Alexandria, in Troas: and a fifth from Magnesia, in Asia." He further says that iron cannot resist it; "the moment the metal approaches it, it springs toward the magnet, and, as it clasps it, is held fast in the magnet's embrace." It is by many called *ferrum vivum*, or quick iron.

Claudian speaks of it as "a stone which is preferred to all that is most precious in the East. . . . Iron gives it life and nourishes it."

Hippocrates, the father of medical science, calls it "the stone which carries away iron."

Epicurus, an Athenian of the Egean tribe, says: "The *loadstone or magnet* attracts iron, because the particles which are continually flowing from it, as from all bodies, have such a peculiar fitness in form to those which flow from iron that, upon collision, they easily unite. . . . The mutual attraction of *amber* and like bodies may be explained in the same manner."

Cardanus intimates that "it is a certain appetite or desire of nutriment that makes the loadstone snatch the iron. . . ."

Diogenes Apolloniota (lib. 2, "Nat. Quæst.," cap. 23) says that "there is humidity in iron which the dryness of the magnet feeds upon."

Cornelius Gemma supposed invisible lines to stretch from the magnet to the attracted body, a conception which, says Prof. Tyndall, reminds us of Faraday's lines of force.

Lucretius ("Nature of Things," Creech transl. 1714), in explanation of verse 1,030, states that "the adhesion of the steel to the loadstone is made in this manner: On the surface of the magnet there are hooks, and, on the surface of the steel, little rings which the hooks catch hold of." (See Lucretius at B. C. 60–56.)

Thales, Aristotle, Anaxagoras of Clazomene and the Greek sophist Hippias ascribe the loadstone's attractive virtue to the *soul*, with which they say it is endowed. De Humboldt ("Cosmos," Magnetic Needle) says *soul* signifies here "the inner principle of the moving agent," and he adds in a foot note: "Aristotle ('De Anima,' I., 2) speaks only of the animation of the magnet as of an opinion that originated with Thales. Diogenes Laertius interprets this statement as applying also distinctly to amber, for he says 'Aristotle and Hippias maintain as to the doctrine enounced by Thales.'"

The native magnet appears to have long been known in nearly every quarter of the globe. (Humboldt, "Cosmos," vol. V., and Harris, "Rudimentary Magnetism," parts I. and II.)

In the Talmud, it is called *achzhib 'th*, the stone which attracts: in the Aztec, *tlaihiomani tetl*, the stone that attracts by its breath; in the Sanscrit, *ayaskánta*, loving toward iron; in the Siamese, *melek*, that which attracts iron; in the Chinese, *thsu-chy*, love stone, also *hy-thy-chy*, stone that snatches up iron: in the French, *l'aimant*, and in the Spanish, *iman*, loving stone: in the Hungarian, *magnet kö*, love stone: while in the Greek it is called *sideritas*, owing to its resemblance to iron.

Euripides called it *lapis herculaneus*, from its power over iron, and it was also known as *lapis heracleus*, doubtless because the best was, at one time, said to be found near Heraclea, in Lydia. (Plato, "Ion" (Burgess), vol. IV., p. 294. See also Blavatsky, "Isis Unveiled," vol. I., p. 130.)

It has likewise been designated as follows: Chinese, *tchu-chy*, directing stone; Icelandic, *leiderstein*, leading stone; Swedish, *segel-sten*, seeing stone; Tonkinin, *d'an-amtchûm*, stone which shows the south; and, by reason of its great hardness, the Greeks called it *calamitas*, the French, *calamite*, also *diamant*; the Hebrews, *khalamish* or *kalmithath*, and the Romans, *adamas*, while *adamant* was the name given to the magnetic needle (compass) by the English of the time of Edward III.

"This stone adamas is dyuers and other than an Magnas, for yf an adamas be sette by yren it suffryth not the yron come to the magnas, but drawyth it by a manere of vyolence fro the magnas." (Trevisa, "Barth. de P. R." XVI., 8.)

"The adamant cannot draw yron if the diamond lye by it." (Lyly, "Euphues," sig. K., p. 10.)

"Right as an adamound, iwys, can drawen to hym so. tylly the yren." ("Rom. Roae.")

"In Ynde groweth the admont stone . . . she by her nature draweth to her yron." (Caxton, "Myrrour," II., VII., 79.)

"The adamant placed neare any iron will suffer it to be drawen away of the lodestone." (Maplet, "Greene Forest," I.)

"You draw me, you hard-hearted adamant; but yet you draw not iron; for my heart is true as steel." (Shakespeare, "Midsummer Night's Dream," Act II., Scene 1.)

"As sun to day, as turtle to her mate, as iron to adasmant." (Shakespeare, "Troilus and Cressida," Act III., Scene 2.)

"The grace of God's spirit, like the true load stone or adamant, draws up the yron heart of man to it." (Bishop Hall, "Occas. Medit.," 52.

"The adamant . . . is such an enemy to the magnet that, if it be bound to it, it will not attract iron." (Leonardus, "Mirr. Stones," 63).

According to Beckmann (Bohn, 1846, pp. 86 to 98), the real *tourmaline* was first brought from Ceylon where the natives called it *tournamal*) at the end of the seventeenth or beginning of the eighteenth century. (See A. D. 1707.)

It is classed by Pliny as a variety of carbuncle (lib. 37, cap. 7); John de Laet says ("De Gemmis," 1647, 8vo, p. 155) "The description of the *lyncurium* does not ill agree with the hyacinth of the moderns"; Watson thinks likewise (Phil. Trans., vol. LI., p. 394), and so does John Serapion ("Lib. de simplicibus medicinis" Argent., 1531, fol., p. 263): while Epiphanius ("De Gemmis," XII.) states that he could find in the Bible no mention of the *lyncurium*, which latter he also believes to have been the hyacinth. On the other hand, the Duke de Noya Caraffa (Recueil de Mem. Æpinus," Petersb., 1762, 8vo, p. 122) considers the *tourmaline* to be identical with the *theamedes* of the ancients.

The *betylos* has doubtless been likewise named in this connection. Strabo, Pliny, Helancius—all speak of the

electrical or electromagnetic power of the betyli. They were worshiped in the remotest antiquity in Egypt and Samothrace as magnetic stones "containing souls which had fallen from heaven;" and the priests of Cybelè wore a small betylos on their bodies. ("Isis Unveiled," vol. I., p. 332). See Enfield "Dict. Phil.," I., 152; Bostock's Pliny, book 37, chap. 12; Azuni, "Boussole," 1809, p. 37; Venanson, "De l'Invention de la Boussole Nautique," Naples, 1808, pp. 27–29; Thomas, "Sc. An.," 1837, p. 250. See also De Noya, "Encyclopædia Britannica," 1855, VIII., p. 529, and Priestley, "History of Electricity," 1775, p. 293.

Electrical Means for Harbor Defence.

Public attention is just now being drawn to the unprotected state of American harbors, more especially that of New York. Unquestionably the means of defence are most inadequate, but the case is generally somewhat overstated by the alarmist faction. We have at present no guns in the forts about New York capable of seriously impeding the progress of a powerful modern ironclad. Guns of the most formidable character are under way, to be sure, but to manufacture them requires no small amount of time, and at present there are barely enough to satisfy the needs of our growing navy. A very few high power guns of moderate size, and still fewer dynamite guns, are about the only strictly offensive weapons available for the defence of New York. But, nevertheless, as regards defensive weapons the case is by no means so bad. It must be remembered that the approaches to the New York harbor are by no means easy for vessels of large draught. The ship channels are none too deep, are narrow and rather crooked; for a long distance off the lower bay the water, except in very contracted regions, is too shallow to permit of a heavy armor clad venturing toward the Narrows. As regards the possibility of lying in deep water off Coney Island and shelling New York, such a contingency is most feared by those who know the least about the ballistic properties of heavy ordnance. In the first place the actual range of the great guns like those on the Duilio, and ships of that class, is considerably exaggerated, and the available range with the elevations possible on board ship is very much less than the maximum range. It is quite doubtful if any ordnance officer would care to fire a 110-ton gun at an elevation to give anything like its maximum range, and even if he were so disposed it could only be done by heeling the ship to an extent that would be more than likely to expose the sides of the vessel below the armor belt. So the problem of defending New York is somewhat simplified, and reduces itself to making certain lanes and patches of deep water within gun shot of the city untenable. The government is tolerably well equipped with devices for this particular purpose, and the present article is intended to call attention to a particular line of defence that is of peculiar interest to electricians.

The Sims-Edison electric torpedo has been more or less completely described in these columns during the various stages of its progress, but it has now reached a practical stage of development and its possibilities as a means of harbor defence are of no mean order. Fig. 1 gives a very good general idea of the mechanism of this peculiarly formidable weapon. It consists of two distincts parts, a float and the torpedo proper suspended far enough below the surface of the water to be out of the way of shot. The float carries a pair of signals that protrude above the surface enough to be seen with tolerable facility. The torpedo proper in its various sizes is from a little under to a little over 30 feet in length, and from 18 inches to two feet in diameter. It consists practically of three sections; first, the slender conical bow, containing a charge of explosive gelatine in considerable amount, rising as high as 450 pounds in some of the models. Next comes a section of the torpedo devoted to the controlling cable, which is paid out through a tube that serves at once to direct the cable and as a skeg to protect the screw. This controlling cable supplies current to an electric motor located immediately aft of the cable coil. Fifteen or 20 h. p. is needed to drive the torpedo at its maximum speed of nearly 20 miles an hour. Steering is accomplished electro-magnetically through the medium of a polarized relay actuated from the shore. Fig. 2 shows the method of using a Sims-Edison torpedo for harbor defence. The dynamo and engine that furnish the propelling current can be safely stowed away underground, and out of the reach of hostile shot. The torpedoes can be put out of harm's way, as shown in the cut, in an underground basin, only communicating with the harbor through a narrow channel that can be easily kept out of danger. Only a single operator is needed to manipulate the apparatus, and he can be concealed at any convenient point from which the course of the torpedoes can be watched. Once under way the torpedo darts forward at the rate of nearly 20 miles an hour, and can be steered with infallible accuracy toward the object of its attack, while its course can be watched by the two slender signals that rise from the float, or from the back of the float itself. No seamanship can avert such an attack, for every turn of the doomed ship is met by a corresponding turn of the torpedo, the most fatal point of attack can be calmly picked out and the torpedo driven to its mark. The full range attained rises as high as two miles, and the speed is so high that the attack cannot be avoided. In fact, it is impossible either to fight or run when assailed by these automobile torpedoes, for the working parts of the machine are out of reach below the surface, and the float cannot be harmed, for it is made of thin metal and packed with some light material impervious to water, lampblack being rather a favorite substance for the purpose. Even if the float were riddled by shot from rapid fire machine guns, the progress of the torpedo would be unimpeded, for it would have reached its mark long before the float would become waterlogged; indeed, the chances of hitting the float at all are very minute. Fig. 3, from an instantaneous photograph of a Sims-Edison torpedo on the warpath, shows how small the chances of a successful defence would be. Torpedo nets, that would always be thrown about an attacking vessel, would only serve as a temporary obstacle, for, as shown in Fig. 2, the torpedoes can be made to hunt in pairs, the first one breaking the protecting devices, the second and following one blowing the bottom out of the ship. Altogether, this automobile torpedo is a very ugly customer, and, inasmuch as the torpedo station at Newport is tolerably well provided with them, in addition to Whitehead, Nordenfeld, Howell and other automobile torpedoes, besides plenty of fixed

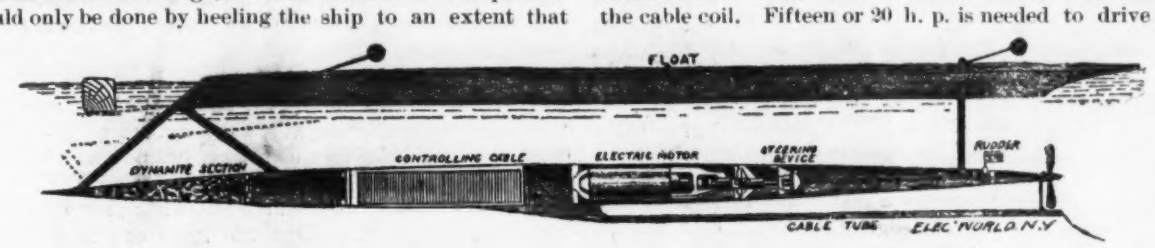


FIG. 1.—DETAILS OF CONSTRUCTION OF SIMS-EDISON TORPEDO.

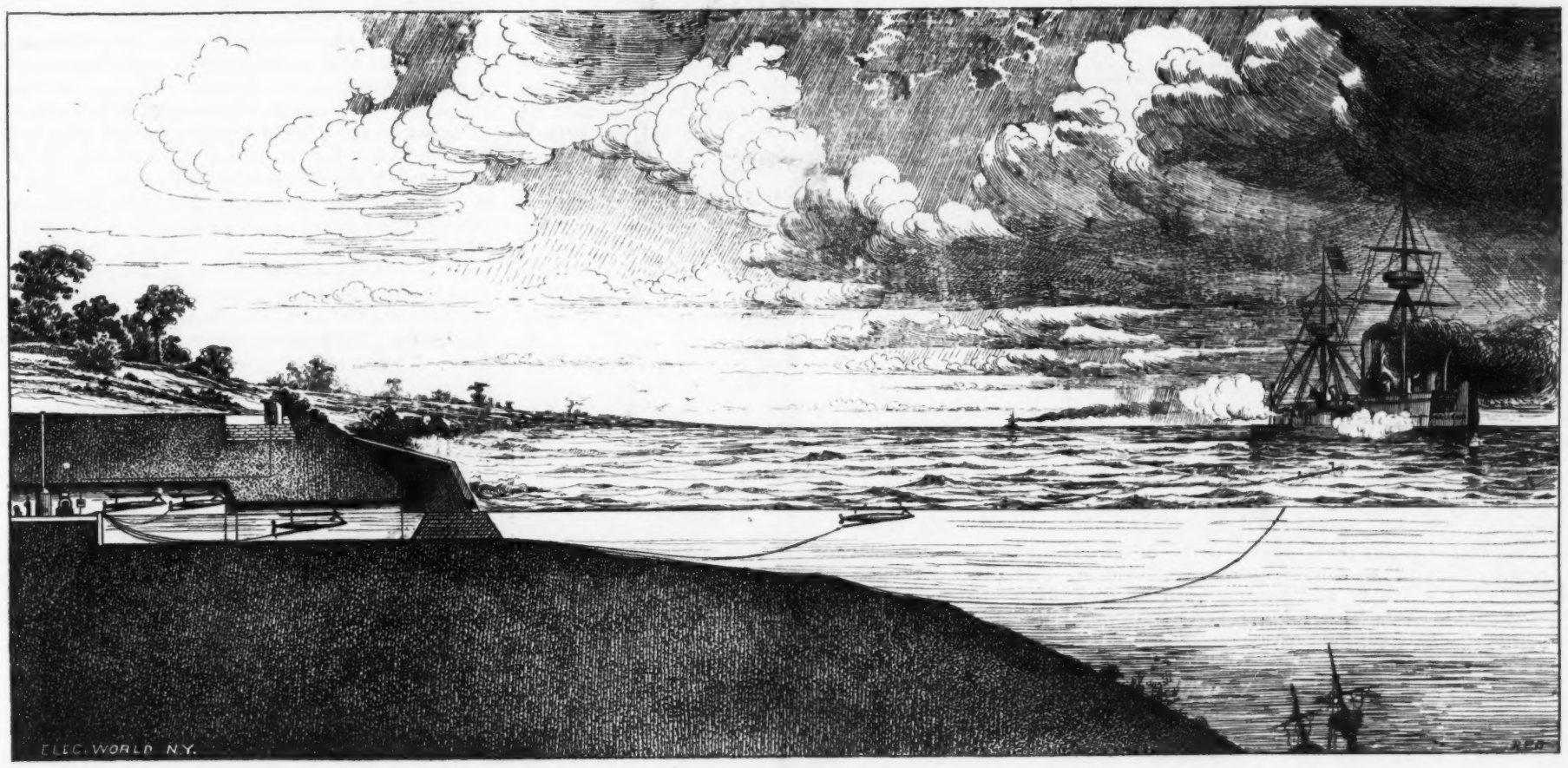


FIG. 2.—CONSTRUCTION OF A TORPEDO STATION, SHOWING METHOD OF OPERATING THE SIMS-EDISON TORPEDO.

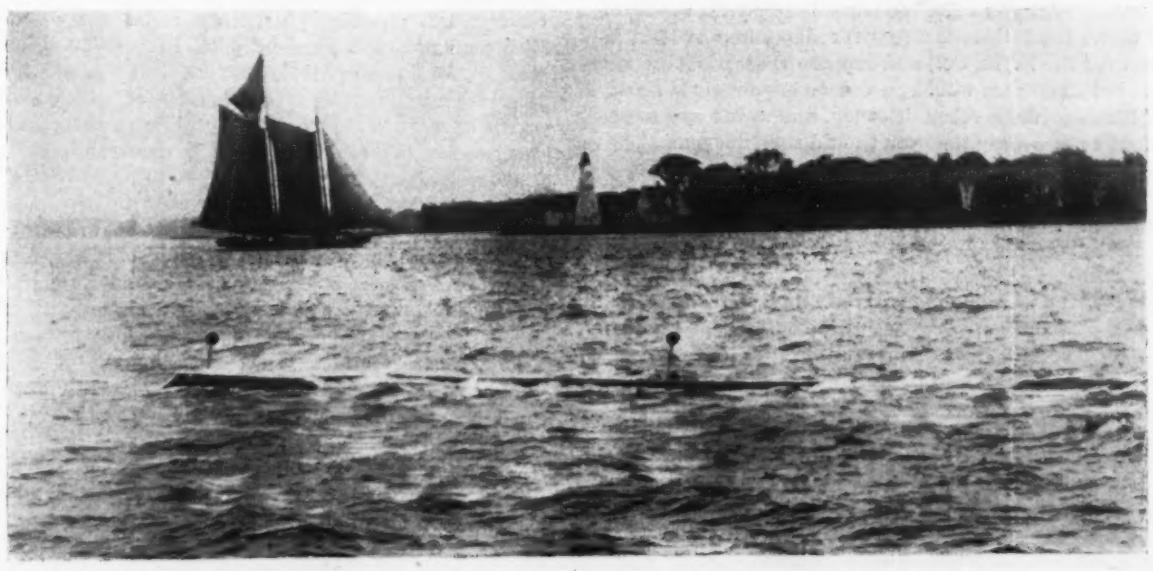


FIG. 3.—THE SIMS-EDISON TORPEDO UNDER WAY.
(From an Instantaneous Photograph.)

mines to be exploded by electricity under the incoming enemy, we may feel sure that a very active defence can be made in case of need. We have plenty of rapid fire guns to interfere with the operations of torpedo catchers, and an attack by dirigible torpedoes could hardly fail of its destructive result. It is such deadly mechanisms as the Sims-Edison, Lay and Halpin-Savage torpedoes that are most to be dreaded in actual war; for torpedoes like the Whitehead, of which control is lost immediately it is fired, are of rather doubtful utility in actual combat, if we may judge by the experience gained from the few cases in which they have actually been used, uniformly without success. The electrician is of no small importance in modern war, and in time of need we can be well assured that his ingenuity would find ways of improving even on the beautifully ingenious weapon we have been describing.

Some Correspondence of Thomas Davenport.

The following letters are part of the correspondence that passed between Thomas Davenport, the inventor of the electric motor in this country, and the Hon. Elijah Paine, Justice of the New York Supreme Court. Mr. Paine was keenly interested in the progress of the newly discovered science of electromagnetism, was Mr. Davenport's financial backer in many of his ventures, and the owner of Davenport's foreign patents. It is evident from the nature of the correspondence that he was fully alive to the importance of electric power, and displayed a remarkably intelligent interest in scientific subjects. The letters certainly form an interesting addition to the early history of electricity in America.

Brandon, July 18, 1838.

Dear Sir—You may have thought me very negligent in not writing you at an ealier date, Brother Thomas and myself having talked about writing for ten days past. Both of us have omitted writing, for the purpose of testing more thoroughly some experiments he has been trying. I suggested to him an experiment, which at once attracted his attention, and the experiment has been made satisfactorily. That is, make two helices, place them very close together, side by side, say one or two inches apart, and insert in them one bolt (or, if you please, a horseshoe or stirrup bolt). You know a horseshoe magnet is said to lift tenfold more than a straight one. Now, sir, we wound the same quantity of wire around the two small helices that we did around one helix of the same form although longer and larger, so as to give it a proper form and size for strength in proportion to the wire we wound upon it, into which we inserted the straight bolt, being only about one-half the length and weight of the bow or stirrup bolt, and we find the bow bolt more than twice as powerful as the straight one. My brother considers it an important improvement. He has also discovered that an iron spring placed under the bolt so as to come in contact with the bolt when it is drawn down is a very sensible benefit. Its attractive power in drawing down the bolt serves as an offset to the force necessary to overcome the spring and bend it down; and then we gain all the strength of the spring in throwing up the bolt. We have built a machine with bolts eight inches long and one inch in diameter, but have not as yet made a good battery, although the machine runs very prettily. We begin to think there is something in the grain of the metal, as we discover the fluid does not run across the grain as well as it does lengthwise, or with the grain, and we intend making a further experiment in batteries.

Brother has made a tin helix, but he is not yet satisfied with the results of his experiments in that article. So you see we are still full of experiments. We are, however, both of us satisfied that the stirrup bolt, with the spring at the bottom, is an important improvement, and we intend to make a model immediately on that plan, which my brother will take pleasure in presenting to you on his arrival at New York. The workmanship may not be the best, but I think you will be pleased with the principle. Will you have the goodness to write me on the receipt of this, and let us know how you get along in the experiments you were about making when we left? I must leave the rest of my sheet to my brother, and subscribe myself very respectfully, your obedient and humble servant,

B. Davenport.

Hon. E. Paine.

Dear Sir—As my brother has invited me to write a few lines in this sheet, I must say that he has done very well in his new occupation of experimenting. He appears determined to excel all experiments in electromagnetism, and I think his improvements are good. I should like to remain in Brandon three or four weeks longer, unless it is highly necessary that I should go to New York. I think the grain of the metal has a good deal to do with the action of a galvanic battery, and that we shall soon obviate all difficulties in regard to batteries. Yours in haste.

Thos. Davenport.

Brandon, Sept. 1, 1838.

Dear Sir—On my return from Williamstown last Saturday week I learned that you left this place on Friday, the day before, for New York. I was detained at Williamstown much longer than I expected, on account of the severe illness of my mother. Since my return I have made some experiments, in which I have ascertained that through the bad arrangements of our machines we lose more than one-half the power, which is in consequence of not allowing the bolt or plunger to move below an *even* [position] with the helix, thus causing too frequent changes of the weight in motion.

To change the motion of any heavy body to produce a reciprocating action consumes a vast deal of power.

Now, if the bolts or stirrups are suffered to pass only even with the helices, and immediately change their motion, the momentum of both bolts and beam is entirely lost; and further, we generally allow the bolts to enter about one-third the distance or length of the helix before the power is applied, and indeed we do not get full power on the bolts until they enter one-half the length of the helix.

I, therefore, have adopted the following plan on a small machine, and shall arrange the large one in the same way:

I let the bolts enter one-half the length of the helices before the power is applied; and when the power is suspended, which is at an even position with the helix, the bolts are suffered to pass through the helix one-half their length by their momentum before the power is again applied, when they are brought back in the same manner to the position in which they started.

Thus we get four inches full power (on a four-inch helix) on each bolt at every revolution, whereas we formerly produced but a little more than two inches of full power, and the power in this last case is applied when the crank is in the most favorable position. The cap or connecting piece to the two bolts or stirrup is detached when the bolts pass through while the power is suspended, and another connecting piece attached on the opposite ends of the bolts while they move back.

I have further ascertained that there ought certainly to be two batteries to each machine (though there need be no more weight than in one), which will give each battery a suspension of action alternately, which I think, very much increases the power.

I think it is very likely that we have not yet the right proportions of the bolts, helices, etc.; and as long as we make as important improvements and discoveries as we have of late, it seems to me advisable to continue experiments a while longer, and even until next spring, before we attempt to introduce it as a motive power either in this country or in Europe. A good one-horse power ought certainly to be produced before we attempt sales of rights, etc., and from my little experience in the business I am satisfied that it cannot be hurried to any profit. I shall alter the large machine, and I am confident that it will produce a beautiful motion and power, and I understand you would like to have it sent to New York. I would inquire whether I had better come myself with it or not, and if you think I had better come please have the goodness to write accordingly.

If you should want to enlist some friends on account of raising funds to go on with, I think this large machine will satisfy them. I will warrant that with $3,000 and my time unmolested until next April I shall have a good one-horse power in operation on a simple and good plan, and I am willing to make any reasonable and consistent sacrifice to you in order to obtain assistance, and shall consider myself obligated to your full satisfaction. I am now *unexpectedly* in want of $600 to satisfy a mortgage on a farm, which mortgage has been sued, and the time for redemption is out the 12th inst. I had the promise of the money here, but have just ascertained that I cannot get it. If you could accommodate me with it it would save me much sacrifice. Will you write me immediately your views, etc.?

I understand there is a receiver appointed by the Chancellor for the E. M. Co., and suppose that probably many of the stockholders would choose to have their business in the hands of some other attorney, and as far as I am concerned I am willing that you should surrender your papers and business with the concern in some other hands if you choose. With a certificate of deposit in any New York bank I can get the money at the banks here. Yours respectfully.

Thomas Davenport.

E. Paine, Esq.

[Postscript.] I have received a number of letters from New York from Capt. Taylor, of the Submarine Company, and T. Cook and others, praying my immediate return, or all business would be prostrated and my reputation destroyed, etc., etc. Perhaps you had better make a settlement with Williams, and let them go their own way. Perhaps it might be advisable to obtain a patent this fall on the new plan, and then advertise that a new discovery had been patented which does not come within the articles of association, etc., that the public may be duly apprised, and thereby prevent any further traffic in the old stock association.

T. Davenport.

Brandon, Oct. 26, 1838.

Dear Sir—I have the pleasure of acknowledging the receipt of yours of the 18th inst., which was received yesterday.

I am now trying some very important and interesting experiments, the result of which I am anxious to ascertain before I leave for New York. The time, I think, will not exceed three weeks before my departure.

I imagine we can make a profitable use of the hydrogen gas we manufacture when using sulphuric acid in solution, by adding to our machiue a "*gas vacuum engine*," similar to one I find recorded in the Engineers and Mechanics' Encyclopedia, vol. 1, p. 613.

I doubt whether any unfavorable opinions at the present time in regard to this business can have a bad effect in the end, provided experiments can be kept along.

The very fact at *any* time, under what circumstances it may happen, that a large and economical *power* is produced will settle *favorably* public opinion. And that such power will soon be produced I have not the least doubt.

If we cannot obtain means sufficiently we must take the more time; and if I could have but one, either time or money, I should choose time, for my *ideas* will run without money—yet, we need both.

I think you have formed a just conclusion with regard to you further expenditures, and I am very happy to learn that you are not discouraged in regard to future progress in the business. I have tried your experiment of magnetizing the bolts by winding the crossbar, about four weeks ago, and have decided that it will not work. The reason of the bolts being drawn into the helix appears to be the very operation of magnetizing the bolt as fast as it enters.

The fact is, the higher you magnetize the bolt the less it will draw into the helix, because the helix must charge the bolt higher than it is already charged or it will not draw a particle. Therefore the less the bolt is charged otherwise than by the helix, the stronger it acts. But this is only my judgment from some experiments.

I was in hopes that you would have ascertained ere this how we could do with Messrs. Cook and Williams, and also some others, provided we settle with Williams and put in the new invention. I think Mr. Cook is the principal one to deal with; that is, provided Mr. Williams wants to settle and we could get an *honest* settlement with him. If I could get business so shaped that I could own full one-third of the United States (always reserving to myself the New England States) without any interest in Europe, and get the money which was due me on the old contract and what I have expended of my own, I think I should be satisfied. And besides I would be willing to warrant a good one horse power next spring.

I think you had better ascertain as far you can what can be done (provided I am willing) by the time I come to New York. I would be willing to make a contract for a certain interest with any responsible individual, provided I produce and put in actual operation a good one-horse power by the first of June next in case they should find me suitable means. Please write me soon. Yours respectfully,

E. Paine, Esqr. Thomas Davenport.

Brandon, Jan. 26, 1847.

Dear Sir—As you formerly with myself took a great interest in the application of electromagnetism to propelling machinery, I presume this communication will receive a proper examination. I understand that there is a machine in New York, built on the helix principle, with which they turn iron and wood, and that it works admirably. A description of this machine is given with woodcuts in the New York *Scientific American* of the present month. If you have not disposed of your English patent, there will probably be a chance soon to make something handsome out of it. I think by some recent experiments of mine that nearly one hundred times the power can be obtained with the same amount of zinc surface that was produced in the machine we constructed in New York, but I have not yet completed all the experiments that I have commenced.

I should like to have you write me whether you have disposed of your patent in England. I find the scientific gentlemen who have the charge of the American electromagnetic telegraph line are altogether behind the times in the science of electromagnetism. Mr. A. Vail, superintendent, has published in a work called the "American Electromagnetic Telegraph, with Reports of Congress, etc." (p. 59, January, 1844), that he believes "it has not been recorded or observed that a bar of iron weighing a pound or more could be drawn up into a helix and there sustained in the air, as it were, without support." Just four years after I printed a quarto newspaper with a helix machine, and six years after I invented the helix machine, Mr. Vail made this great discovery. I have the opinions of many with my own that the use of electromagnets to propel Professor Morse's telegraphic apparatus is an infringement on my patent. William P. Elliot, patent agent at Washington, is of the same opinion. You are aware, probably, that my patent gives me the "application of magnetic and electromagnetic power as a moving principle for machinery." I find in Mr. Vail's work above mentioned (p. 53) that Prof. Morse bases his invention on the ground "that electromagnets can be made to act with an inconsiderable battery, too, when the latter is connected with the former by considerable length of wire." It seems to me, on comparing my invention to that of Prof. Morse, that the telegraphic companies, after running their wires a "*considerable distance*" and ascertaining that they can magnetize iron at such a distance, should stop, and contract with me and my associates for the right of using electromagnetic power to propel their telegraphic machinery. But, sir, you are a better judge than myself and I should be happy to have your opinion on the subject, and if you think there are good grounds for action I will propose to you, so far as I am interested, to prosecute or arrange with the companies, just as in your judgment may be best. Whatever amount may be obtained so far as my interest goes, I am willing that you should retain one-half as fees for your services. Mr. Daniel Davis, Jr., of Boston, has for a number of years carried on an extensive business in manufacturing electromagnetic machines for philosophical purposes. Is not he

infringing also? How would an *injunction* upon these depredators do? My pecuniary circumstances for a few years past have been such that I have been obliged to experiment on a very small scale, but I have been encouraged by many that, should I petition Congress, I could get an appropriation of funds to aid me in furthering the great object of producing an available power by electromagnetism. The Hon. S. Foot, M. C., writes to me favorably on the subject. In consultation with my brother, Barsillia, we have concluded that, as you are acquainted with my case, if you think favorably of the course, and will lend your influence, we shall send in a petition to Congress the present session. The Supreme

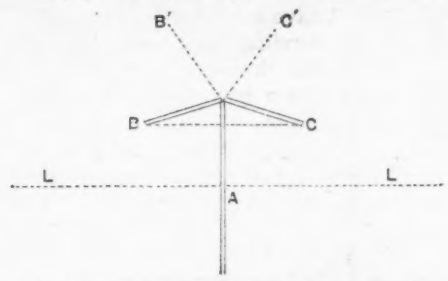


FIG. 1.—ARRANGEMENT OF BUNSEN PHOTOMETER. PLAN.

Court sits in Rutland next week, and we should like a line from you if possible, in season, while the court is in session, on account of getting the names of the judges and some others to the petition, if it is thought best to make use of one. I should be pleased, sir, to receive a line from you as soon as convenient. Respectfully yours,

THOMAS DAVENPORT.

P. S.—Dr. T. P. Jones says, in the *Journal of the Franklin Institute*, vol. 20, No. 5, of Nov., 1837, that if electromagnetism was practically applied to telegraphic purposes it would be due to the recent experiments and discoveries on the subject of electromagnetism in this country.

Hon. ELIJAH PAINE,
Counsellor at Law, New York.

Photometers.*

Practical photometry does not enter into the ordinary work of an electrical engineer. Most of our readers are familiar with the general principles, and every technical college is provided to a greater or less extent with photometers "for educational purposes," and occasionally with a properly fitted photometric bench. The eye is utterly unable to estimate illumination quantitatively. We cannot tell whether one light is twice as bright as another, or if it is only once and a half times as powerful. Every electrical engineer knows that eight-candle lamps are more easily distinguished from sixteen-candle by the size of the bulb than by the light yielded. Photometrical measurements are therefore always made by the comparison of illuminations, and a null or zero method is adopted, the skill of the observer being directed to the adjustment of the apparatus until the two illuminations appear to him to be identical. This amounts to a relative quantitative estimate of two sensations. Our various senses are very keen in detecting small *qualitative* differences. Thus the eye can detect, according to Aubert, at least 1,000 different simple colors, while, allowing for mixtures, there must be between two and three million dis-

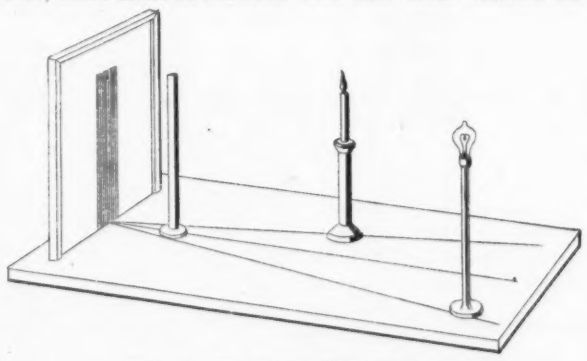


FIG. 4.—RUMFORD PHOTOMETER.

tinguishable tints. A practiced ear, according to Weber, can recognize one sixty-fourth of a semitone, or a difference of one vibration in a thousand; but for all that it is impossible to say whether one sound is half as loud as another. The exactness of quantitative estimation becomes, then, generally merely a matter of the limit within which two sensations appear to be identical. If an unpracticed observer puts two equal lights at the opposite ends of a photometer bar 100 inches long, and places the screen 1 inch from the centre, he will probably fail to see any difference in the two illuminations. The actual difference is equal to the difference between 49^2 and 51^2, or eight per cent. Practice will soon reduce the limit of error to rather less than half this, but no elaboration of apparatus, whether as to facilities for adjustment, sensitive screens, or accurately standardized sources of illumination, will make the measurements more accurate. A large number of readings from different directions, with the graduated scale hidden from the observer until he has made the adjustment, will give an average to an imposing number of decimals, but the probable error must still remain large, as compared with most scientific measurements.

Photometric measurements up to about 6 to 10 per cent. are very easily made, and the apparatus required is of the most simple character. A greater accuracy is only to be attained by carefully screened instruments or the use of a dark room, together with considerable practice and training.

The two most simple photometers are those of Bunsen and Rumford. The essential part of the former is generally a piece of white paper with a grease-spot. When this is brightly illuminated on one side, the grease-spot, seen from that side, appears to be darker than the rest of the paper. Seen from the other side, it appears brighter. In the former case the difference in tint between the spot and the surrounding paper is practically the same from whatever angle it is seen; but in the latter the spot appears brighter as the eye is brought into a line with the light behind it. It would seem at first as though the grease-spot would disappear when the illumination is the same on both sides. But it is clear that the light falling on the paper screen is affected in three different ways—reflection, absorption and transmission; and it is the absorption which introduces the difficulty. In practice it is usual to arrange two mirrors inclined at such an angle that the two sides of the screen may be seen simultaneously. Then, whatever may be the relation between the reflection, the absorption and the translucency, it is sufficient to adjust the screen until the reflected images appear to be identical.

The plan of the arrangement is shown in Fig. 1. *A* is the screen, *L L* the axis of the light, or the line joining the two sources of illumination. *B* and *C* are two mirrors in which reflections of the screen appear as if at B^1 and C^1. The projecting sides of *B* and *C* throw a shadow on the screen. Fig. 2 shows the appearance of the reflection, the two images of the grease-spot being separated by the shadow. In order to avoid this a prism has been used. Two images of the screen *A* (Fig. 3) are seen through the prism *B*, as shown by the dotted lines. The images are, however, necessarily very much foreshortened. In either

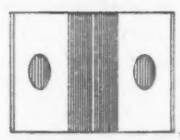


FIG. 2.—IMAGES OF BUNSEN SCREEN AS SEEN IN THE MIRRORS.

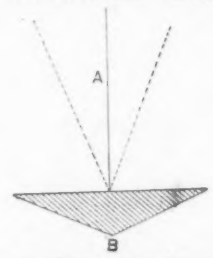


FIG. 3.—PRISM FOR SHOWING BOTH SIDES OF BUNSEN SCREEN.

case the arrangement is symmetrical, and the images are equally inclined to the eye.

For ordinary laboratory work the screen is enclosed in a blackened tube, which shuts out all stray light; and this tube is mounted upon a carriage sliding or running on wheels on a graduated bar. A pointer for reading the scale is covered by a hinged door, in order that the observer may not be biased while making an adjustment. If the scale be visible there is always a temptation to look at it, and to make the reading approximate to a previous one, or to some preconceived value.

The illumination varies inversely as the square of the distance of the screen from the light. If the screen is found to make a balance when it is situated at 25 inches from one end of a 100-inch bar, the lights being 100 inches apart, one is nine times as powerful as the other, the screen being, of course, nearer the lesser light. If a balance was found at 20 inches, the ratio of the lights would be as 16 to one, or as the square of 80 is to the square of 20.

The Rumford photometer is not so common as the Bunsen, but it possesses several important advantages. It consists of a screen and a rod (Fig. 4). The two lights to be compared are so arranged that they cast two shadows side by side upon the screen. The distance of the rod from the screen does not affect the calculation, and it should be so arranged that the shadows exactly meet without overlapping. The two tints to be matched falling next to each other, a considerable degree of accuracy is possible, and the observation does not depend on the angle at which the screen is seen, nor are any mirrors or restricted view necessary. A modification of this is the Bouguer or Foucault photometer, in which the rod is replaced by a partition, which allows one side of the screen to be illuminated by one light only. The partition is capable of adjustment, by which the junction of the shadows may be arranged. The screen is translucent, and may be made of opal glass or paper.

The Bunsen photometer is undoubtedly the favorite in England and Germany, while, until recently, the Rumford and Foucault was the most popular in France. One advantage possessed by the former is, that a diffused light can be compared with one of high intrinsic brilliance without difficulty. Indeed, it is impossible to tell, on a Bunsen screen, if the light is diffused or not. Shadow photometers are easy to work with, since the screen can be observed directly, but if one light be more diffused than the other, the edge of one shadow will be more soft than that of the other. Instead of a round grease-spot, a star-shaped spot is often employed with a Bunsen photometer, and this may be easily made by soaking blotting paper uniformly in white wax or paraffine. When cool, the blotting paper may be cut into a star or other shape, and placed on a sheet of white paper covered with another, and pressed with a hot iron. With a little practice very sharp-edged spots may be produced. With suitable paper a very perfect disappearance can be obtained, and so sensitive is an elaborate star-spot, owing to its extent of edge, that greater accuracy and certainly greater speed may be attained than with the mirror method. Complete disappearance, however sensitive the spot may be, does not mean a balance, and the photometer scale must be empirically graduated by means of two equal lights. The disadvantage of this method is that the graduation will differ from different spots and different papers. A very good screen, and one which may be easily reproduced if injured or soiled, can be made from two pieces of very translucent paper, with an opaque white piece, having a star-shaped opening between them.

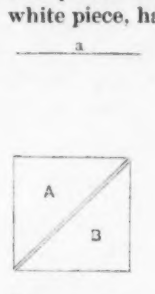


FIG. 5.—ELEMENTARY ARRANGEMENT OF LUMMER AND BRODHUM PHOTOMETER.

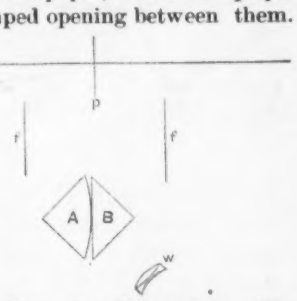


FIG. 6.—PRACTICAL ARRANGEMENT OF PRISMS AND SCREEN WITH MIRRORS.

The middle piece of paper may be replaced by a sheet of tinfoil.

The principle of the Bunsen photometer is sufficiently obvious, but some mathematics have been expended on it. The spot is more or less transparent, the rest of the screen is more or less a reflector. Both the transparency and the reflection are necessarily imperfect or diffusive. A silvered glass, with a portion of the reflecting surface removed, could not, under ordinary circumstances, be used as a Bunsen screen. But the imperfections of such a screen, the absence of simultaneous disappearance of the spot on both sides, the uncertainty of the line of separation on the edge of the spot and the necessity for the use of mirrors, have led MM. Lummer and Brodhun, of the Physico-Technical Institute, of Berlin, to design a very sensitive photometer, in which they retain the main principle of Bunsen, but avoid the difficulties arising from the imperfect translucency and reflection.

In its most elementary form the photometer consists of two screens, *a* and *b*, Fig. 5, which may be either translucent or opaque. The former would be the best for very powerful lights, the latter would be suitable for ordinary purposes, and it would be much more easy to insure the equality of their reflecting power than equality in the transparency of opal or semi-opaque screens. A pair of glass prisms, *A* and *B*, are placed face to face, and are united by a drop of Canada balsam or other transparent cement of about the same refractive index as the glass. From the direction *O*, the screen *a* is observed direct through the prisms, since they are brought into optical contact by the cement. The screen *b* is seen by reflection from the inner surface of the prism *B*. This surface may be silvered, and the silvering removed at the centre. A more perfect arrangement is shown in plan in Fig. 6, and a general view is given in Fig. 7, which is reproduced from an article by M. Palaz in *La Lumière Electrique*.

The direction of the light through the prisms is such that total internal reflection takes place in prism *B*. The face of prism *A* is rounded, and is pressed firmly against *B*,

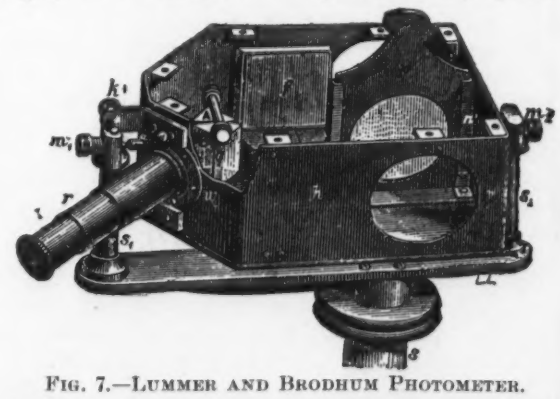


FIG. 7.—LUMMER AND BRODHUM PHOTOMETER.

bringing the surfaces into optical contact. To avoid Newton's rings a little Canada balsam may be used. A telescope is hardly necessary, but one has been provided by the inventors, and through it the prisms are seen. Instead of two screens, as in Fig. 5, a single screen, *p*, is employed. This is opaque, and should have a high reflective power, but this reflection must be diffusive. At *f* and f^1 are two mirrors placed symmetrically with respect to the screen *p* and the prisms *A* and *B*. The screen is placed on the usual photometric bench, the light from the two sources falling perpendicularly on it. The diffused light from the screen falls on the mirrors, and is thence reflected prependicularly on the prisms. In its practical form the mirrors and prisms are enclosed in a box, *h*, mounted on an axis. The two pillars, *s* and s_2, support the box by means of the set screws, *m*, allowing it to swing in a horizontal plane. The prisms *A* and *B* are pressed together by a clamp, *q*. The opaque screen *p* slides in a frame, and passes through a slot in the cover of the box. The light falls on the screen through the side openings. This photometer, on account of the absence of absorption and the exact balance which can be obtained, is very much more sensitive than any form of Bunsen.

* From *The Electrician*, London.

The Magnetic Circuit of Transformers: Closed Versus Open.*

BY S. EVERSHED.

(43) Suppose No. 2 closed transformer is run by an alternator giving a zigzag E. M. F. wave (Fig. 11). Of course no such alternator exists, every practicable machine having the angles of the zigzags rounded off to some extent, but the plain zigzag can be looked on as a limiting curve more or less closely approached by some actual generators. In dealing with zigzag functions, such old friends as

$$\text{effective } E = \frac{\text{maximum } E}{\sqrt{2}}$$

and mean power $= \frac{\text{max. } E \times \text{max. } C}{2} \cos$ (angle of lag)

must be abandoned. If A' is the maximum value of a zigzag function, and T the period, the equation to the "curve" from

$$t = 0 \text{ to } t = \frac{1}{4} T$$

is $$y = \frac{4 A'}{T} t$$

and the mean square of y is

$$y^2_m = \frac{4}{T}\int_0^{\frac{T}{4}} \frac{16 A'^2}{T^2} t^2 dt = \frac{A'^2}{3},$$

so that the effective value of y is $\frac{A'}{\sqrt{3}}$.

The mean value of y is, of course, $\frac{A'}{2}$, so that mean value $=$ effective value $\times \frac{\sqrt{3}}{2} = .87 \times$ effective value. To find the expression for the mean power in a circuit in which a zigzag current differs in phase from a zigzag electromotive force, involves a somewhat tedious integration of several terms, for discontinuous functions are here being dealt with, and those of us who are not Oliver Heavisides find it requires very wary walking to avoid a fatal slip into infinity. As the expression when found is of no practical importance, the working out will not be given, but the result may be set down as a curiosity.

Mean power for zigzag E and C having a time lag $= \theta$

$$W = \frac{E' C'}{6}\left(2 - 48\frac{\theta^2}{T^2} + 64\frac{\theta^3}{T^3}\right)$$

E' and C' are the maxima of E and C; T is the periodic time and θ is the lag in time of C behind E. Note that when $\theta = 0$, $W = \frac{E' C'}{3}$, as it ought to be; when $\theta = \frac{1}{4} T$, the factor in brackets vanishes, and $W = 0$; and lastly, when $\theta = \frac{1}{2} T$, and the current is therefore co-phasal with E, but of opposite sign, the bracketed expression becomes -2, and $W = -\frac{E' C'}{3}$, that is to say, the part of the circuit considered is the seat of the electromotive force. With these rough and ready tools we proceed to discuss

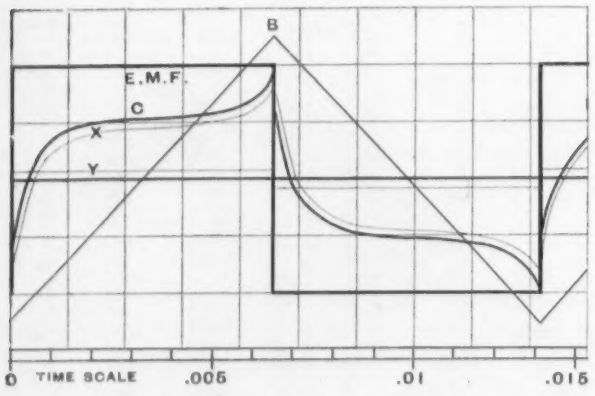


Fig. 12.—No. 2 Closed Transformer Excited by Alternating Constant E. M. F. Output = 0.

the working of transformers by a zigzag E. M. F. wave.

(44) The value of a zigzag E, reckoning time from the epoch when E has its maximum value E', is

$$E_t = E' - \text{at} \qquad = 0 \text{ when } t = \frac{E'}{a},$$

but $E = 0$ when $t = \frac{T}{4}$ so that $a = \frac{4E'}{T}$; now since E is the counter E. M. F. in the primary coil, it is due to $\frac{d\,\mathbf{B}}{dt}$, and is equal to $NA\frac{d\,\mathbf{B}}{dt}$ (A being the area of the core), and we have

$$E_t = NA\frac{d\,\mathbf{B}}{dt} = E'\left(1 - \frac{4}{T}t\right)$$

and therefore $\mathbf{B}_t = \frac{E'}{NA}\int\left(1 - \frac{4}{T}t\right)dt = \frac{E'}{NA}$

$\left(t - \frac{2t^2}{T}\right)$ the equation for $\frac{d\,\mathbf{B}}{dt}$ shows us that $\mathbf{B}$ is a maximum when $t = \frac{T}{4}$ as we should expect, and this value being inserted in the equation for $\mathbf{B}_t$ we have for the maximum value of $\mathbf{B}$

$$\mathbf{B}' = \frac{E'T}{8NA} = \frac{\sqrt{3}ET}{8NA}.$$

Recalling the corresponding expression in the case of a sine function, namely:

$$\mathbf{B}' = \frac{9ET}{104NA} = \frac{3\sqrt{3}}{5}\cdot\frac{\sqrt{3}ET}{8NA},$$

we notice that if E is to be 2,000 volts, we must put $E_z = E_s$, or $\mathbf{B}'NAF$ (for zigzag) $= \frac{5}{3\sqrt{3}}\mathbf{B}'NAF$ (for sine), so that one of the four factors $\mathbf{B}'NAF$, must be reduced in the ratio $\frac{5}{3\sqrt{3}}$, or by about four per cent., in order that the values of E for the sine function and zigzag may be equal. The simplest change to make to keep the

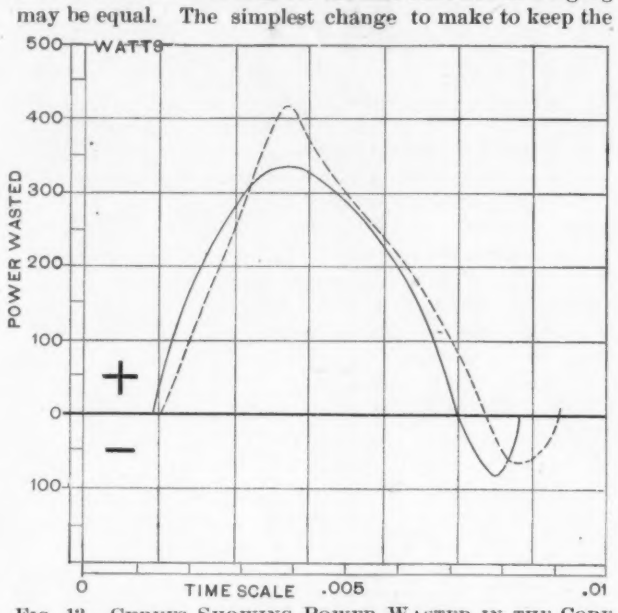


Fig. 13.—Curves Showing Power Wasted in the Core of No. 2 Closed Transformer. The Full Line Corresponds with Sine E. M. F., and Dotted Line with Zigzag E. M. F.

effective E. M. F. right is to reduce the frequency so that the transformer will require no alteration of windings or core, and the induction cycle will be the same as before, namely 5,000 gausses, so that the $\mathbf{B}\,\mathbf{H}$ curve given in Fig. 9 can be used in drawing the new diagram. The frequency will then be reduced from 70 to 66.4 periods per second, and a slight diminution in the hysteresis loss follows as a necessary consequence. The time scale should remain as before, but quarter periods corresponding to the lower frequency (*greater* periodic time) must be marked before the E. M. F. zigzag is drawn. E' is evidently $2{,}000 \times \sqrt{3} = 3{,}470$ volts, and this value is plotted alternately positive and negative at intervals equal to $\frac{T}{2}$ and these points when connected by a zigzag series of lines, complete the E wave.

(45) The induction curve is easily plotted from the equation

$$\mathbf{B}_t = \frac{E'}{NA}\left(t - \frac{2t^2}{T}\right),$$

remembering that T is now $\frac{1}{86.3} = .0151$ second. It is perhaps simpler to eliminate $\frac{E'}{NA}$ by inserting the value found for the maximum induction, viz.:

$$8\,\mathbf{B}' = \frac{E'T}{NA},$$

so that $$\mathbf{B}_t = 8\,\mathbf{B}'Ft(T - 2t).$$

The geometrical student will see a conic section in these equations for $\mathbf{B}$; and in fact the positive and negative waves of induction are a series of parabolas having parallel axes normal to the time axis, spaced at intervals equal to $\frac{1}{2} T$. Where the induction changes sign one parabola ends and the next begins, at which point there is an abrupt change in the *direction* of curvature of the otherwise continuous line. In fact, the value of $\frac{d\,\mathbf{B}}{dt}$, while having the same numerical value for the curves on each side of zero, suddenly changes its sign; this is, of course, only a roundabout way of saying that E at this epoch suddenly changes the sign of its slope. It is interesting to note how very little the parabolic induction wave differs in form from the sine wave in Fig. 10 (*Electrician*, March 20, p. 598) yet how great a change has been brought about in the counter E wave. Note also that the slightest departure from a true parabolic form when carrying the induction wave through zero (so as to make the two parabolas melt into each other with abrupt change) leads to a rounding of the angles in the E zigzag resulting in a curve closely resembling those given by some actual alternators. No calculations are needed before drawing the X component of the exciting current, for a sufficient number of values of X have already been worked out from the $\mathbf{B}\,\mathbf{H}$ curve when making Fig. 10. To draw the Y (eddy current) component of the exciting current we require its maximum value, and the investigation made in the case of the sine function diagram shows that this depends only on the maximum value attained by the $\mathbf{H}$ due to eddy currents, and this again on the maximum of $\frac{d\,\mathbf{B}}{dt}$ or $\dot{\mathbf{B}}$; now clearly

$$\frac{\dot{\mathbf{B}} \text{ for zigzag}}{\dot{\mathbf{B}} \text{ for sine}} = \frac{E'_z}{E'_s} = \frac{3470}{2830},$$

so that the required maximum for Y is

$$Y' = .0225 \times \frac{3470}{2830} = .027 \text{ ampère.}$$

Y can now be plotted, being a zigzag curve co-phasal with E.

(46) The last diagram we shall draw for this transformer (No. 2 closed) is one in which E is assumed to alternate between $-2{,}000$ and $+2{,}000$ volts (Fig. 12), the change from $+$ to $-$ being instantaneous. The induction wave will now be a zigzag, for $NA\frac{d\,\mathbf{B}}{dt} = E =$ constant. In the present case effective E = mean E = maximum E, and $E = 4\,\mathbf{B}'ANF$. Now for a sine wave we had $E = 4.4\,\mathbf{B}'ANF$, so that we must *increase* one of the factors $\mathbf{B}'ANF$, in order to make $E = 2{,}000$ volts. As before, we will alter the frequency, making it $F = \frac{4.4}{4}$ (F for a sine) $= 77.6$ periods per second. It must be noticed here that if the frequency is worked out from the equation $E = 4\,\mathbf{B}'ANF$, by inserting the known values of E $\mathbf{B}'$, A and N, the result is $F = 76.4$ instead of 77.6. The discrepancy is due to our original sin in neglecting the fact pointed out in the first article, that $\mathbf{B}'$ is only 4,900 gausses, and not 5,000 as assumed in the whole of the calculations. We must therefore take the value $F = 76.4$ if we make $\mathbf{B}' = 5{,}000$. After plotting E and $\mathbf{B}$, X may be put in, and we note that it is now precisely the same shape as the $\mathbf{B}\,\mathbf{H}$ curve from which it is obtained; in fact it is put on the diagram (Fig. 12) just as though the cyclic loop had been placed with its $\mathbf{B}$ axis along the time axis of the diagram, and the loop then cut at one of its turning points, and the negative portion folded forward along the time axis. Of course the values of $\mathbf{H}$ are replaced by the corresponding values of C before carrying out the operation. The Y component is of the same form as the E wave, and its value (which is constant) is found by precisely the same method as we have described in connection with Figs. 10 and 11.

$$C' = Y' = .0156 \text{ ampère.}$$

(47) The waste of power may be obtained from the diagrams by taking the product of E and C at short intervals of time, and using these products as ordinates in a power curve, the area of which—best taken by a planimeter—divided by the time, gives the mean power wasted in the transformer core at *no* load. The power curves for No. 2 closed transformer run by a sine and a zigzag E. M. F. will be found in Fig. 13. In each there is a time during which the power is negative, the core giving back to the circuit a small part of the energy previously put into it. The negative area must be deducted from the positive area before dividing by $\frac{1}{2} T$ to obtain the mean power. These curves show that the *shape*

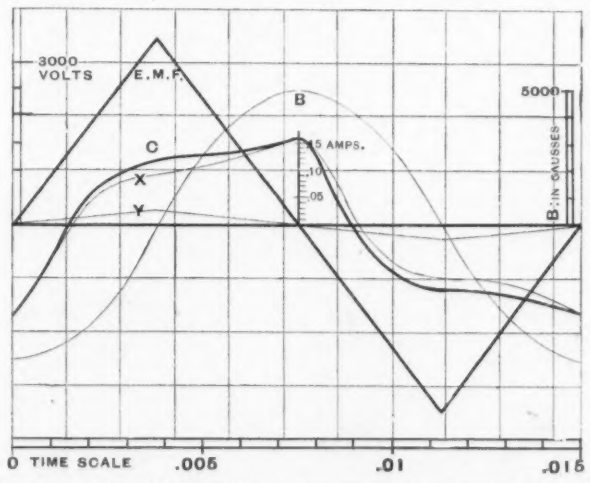


Fig. 11.—No. 2 Closed Transformer Excited by Zigzag E. M. F. Output = 0.

of the E wave has very little influence on the total waste of power in the core, a result which the reader has doubtless foreseen from the beginning of this investigation, for the hysteresis loss depends only on the maximum induction and number of reversals per second, and, the former having been kept constant and the latter only slightly varied, the variation in waste power from this cause can only be small. The hysteresis loss then varies *directly* as the frequency, other things remaining constant. The eddy current loss for a given shape of E. M. F. wave also varies directly, but as the *square* of the frequency, for it will be remembered that the expression for the power wasted in eddy currents contains the factor $\dot{\mathbf{B}}^2$, which is proportional to the square of the maximum induction and square of the frequency. But the eddy current loss depends on something besides frequency. When a given total change of induction takes place within a certain area in a given time, the waste power in eddy current in conductors surrounding the area depends on the law governing the rate at which the induction varies during the whole time occupied by the change.

(To be continued.)

*Continued from The Electrical World, April 18, 1891.

TABLES OF WIRE GAUGES.*

American and European, with Cross Sections and Diameters Arranged for Comparison and Reduction.

Gauges and Scales.							Cross-Section.			Diameter.	
Vulgar fractions of an inch.	Millimetre scale (diam. in millimetres).	Decimal scale (diam. in mils).	Edison gauge.	Birmingham, or Stubs (Holzapffel) or old English standard gauge. B. W. G.	New British or standard gauge (March 1, 1884).	American or B. & S. gauge.	Circular mils (= d^2) (1 circular mil = .7854 square mils).	Square mils (1 sq. in. = 1,000,000 sq. mils).	Square millimetres (1 sq. mm. = 1550.1 sq. mils).	Millimetres (1 mm. = 39.3708 mils).	Mils (= d) (1 inch = 1,000 mils).
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
1	.....	1000	.....	.....	.....	.....	1000000.	785398.	506.69	25.400	1000.00
31/32	.....	969	.....	.....	.....	.....	938961.	737869.	476.00	24.606	969.00
15/16	.....	938	.....	.....	.....	.....	878844.	691061.	445.77	23.812	937.50
29/32	.....	906	.....	.....	.....	.....	820836.	645354.	416.32	23.019	906.25
7/8	.....	875	.....	.....	.....	.....	765625.	601745.	388.18	22.225	875.00
27/32	.....	844	.....	.....	.....	.....	712336.	560233.	361.34	21.431	843.75
13/16	.....	813	.....	.....	.....	.....	661344.	520018.	335.42	20.638	812.50
25/32	.....	781	.....	.....	.....	.....	612656.	481699.	310.71	19.844	781.25
3/4	.....	750	.....	.....	.....	.....	562500.	441786.	285.01	19.350	750.00
23/32	.....	719	.....	.....	.....	.....	517056.	406578.	262.24	18.256	718.75
11/16	.....	688	.....	.....	.....	.....	473344.	372174.	240.03	17.463	687.50
21/32	.....	656	.....	.....	.....	.....	430336.	338377.	218.24	16.669	656.25
5/8	.....	625	.....	.....	.....	.....	390625.	306796.	197.93	15.875	625.00
.....	.....	.....	360	.....	.....	.....	360000.	282743.	182.41	15.240	600.00
.....	.....	.....	340	.....	.....	.....	340006.	267040.	172.28	14.810	583.10
.....	.....	.....	320	.....	.....	.....	320005.	251332.	162.14	14.365	565.69
.....	.....	.....	300	.....	.....	.....	300008.	235626.	152.01	13.912	547.73
.....	.....	.....	280	.....	.....	.....	280010.	219920.	141.88	13.440	529.16
.....	.....	.....	260	.....	.....	.....	260008.	204210.	131.74	12.952	509.91
1/2	.....	500	.....	.....	7 0	.....	250000.	196350.	126.68	12 700	500.00
.....	.....	.....	240	.....	.....	.....	240002.	188497.	121.61	12.443	489.90
.....	.....	.....	220	.....	.....	.....	220008.	172794.	111.48	11.914	469.05
.....	.....	.....	.....	.....	6 0	.....	215296.	169093.	109.09	11.785	464.00
.....	.....	.....	.....	.....	.....	0000	211600.	166190.	107.22	11 684	460.00
.....	.....	.....	.....	0000	.....	.....	206116.	161883.	104.44	11.531	454.00
.....	.....	450	.....	.....	.....	.....	202500.	159043.	102.61	11.430	450.60
.....	.....	.....	200	.....	.....	.....	200006.	157084.	101.34	11.359	447.22
7/16	.....	.....	.....	.....	.....	.....	191406.	150330.	96.98	11.113	437.50
.....	.....	.....	190	.....	.....	.....	190000.	149226.	96.27	11.071	435.89
.....	.....	.....	.....	.....	5 0	.....	186624.	146574.	94.56	10.972	432.00
.....	.....	425	.....	000	.....	.....	180625.	141863.	91.61	10.795	425.00
.....	.....	.....	180	.....	.....	.....	180005	141376.	91.21	10.776	424.27
.....	.....	.....	170	.....	.....	.....	170008.	133524.	86.14	10.473	412.32
.....	.....	.....	.....	.....	.....	000	167805.	131790.	85.03	10.405	409.64
.....	.....	400	160	.....	4 0	.....	160000.	125664.	81.07	10.160	400.00
.....	10	.....	.....	.....	.....	.....	155006.	121740.	78.54	10.000	393.71
.....	.....	.....	150	.....	.....	.....	150001.	117811.	76.00	9.837	387.30
.....	.....	.....	.....	00	.....	.....	144400.	113411.	73.17	9.652	380.00
9/16	.....	375	.....	.....	.....	.....	140625.	110450.	71.25	9.525	375.00
.....	.....	.....	140	.....	.....	.....	140003.	109958.	70.94	9 504	374.17
.....	9.5	.....	.....	.....	.....	.....	139893.	109858.	70.88	9.500	374.02
.....	.....	.....	.....	.....	000	.....	138384.	108687.	70.12	9.448	372.00
.....	.....	.....	.....	.....	.....	00	133079.	104518.	67.43	9.266	364.80
.....	.....	.....	130	.....	.....	.....	130004.	102105.	65.87	9.158	360.56
.....	9	.....	.....	.....	.....	.....	125555.	98588.	63.62	9.000	354.34
.....	.....	350	.....	.....	.....	.....	122500.	96211.	62.07	8.890	350.00
.....	.....	.....	.....	.....	00	.....	121104.	95115.	61.37	8.839	348.00
.....	.....	.....	120	.....	.....	.....	120007.	94253.	60.81	8.799	346.42
11/32	.....	.....	.....	.....	.....	.....	118164.	92810.	59.87	8.731	343.75
.....	.....	340	.....	0	.....	.....	115600.	90792.	58.57	8.636	340.00
.....	8.5	.....	.....	.....	.....	.....	111992.	87958.	56.75	8.500	334.65
.....	.....	.....	110	.....	.....	.....	110005.	86398.	55.74	8.424	331.67
.....	.....	325	.....	.....	.....	.....	105625.	82958.	53.52	8.255	325.00
.....	.....	.....	.....	.....	.....	0	105534.	82887.	53.47	8.251	324.86
.....	.....	.....	.....	.....	0	.....	104976.	82448.	53.19	8.229	324.00
.....	.....	.....	100	.....	.....	.....	100001.	78511.	50.67	8.032	316.23
.....	8	.....	.....	.....	.....	.....	99204.	77914.	50.27	8.000	314.97
13/16	.....	.....	.....	.....	.....	.....	97656.	76699.	49.48	7.937	312.50
.....	.....	.....	95	.....	.....	.....	95005	74617.	48.14	7.829	308.23
.....	.....	300	90	1	1	.....	90000	70686.	45.60	7.620	300.00
.....	7.5	.....	.....	.....	.....	.....	87191.	68479.	44.18	7.500	295.28
.....	.....	.....	85	.....	.....	.....	85001.	66760.	43.07	7.405	291.55
.....	.....	.....	.....	.....	.....	1	83694.	65732.	42.41	7.348	289 30
.....	.....	.....	.....	2	.....	.....	80656.	63347.	40.87	7.213	284.00
.....	.....	.....	80	.....	.....	.....	80004.	62835.	40.54	7.184	282.85
5/32	.....	.....	.....	.....	.....	.....	79102.	62130.	40.08	7.144	281.25
.....	.....	.....	.....	.....	2	.....	76176	59828.	38.59	7.010	276.00
.....	7	.....	.....	.....	.....	.....	75953.	59653.	38.48	7.000	275.60
.....	.....	275	.....	.....	.....	.....	75625.	59390.	38.32	6.985	275.00
.....	.....	.....	75	.....	.....	.....	75005.	58908.	38.00	6.956	273.87
.....	.....	.....	70	.....	.....	.....	70003.	54980.	35.47	6.720	264.58
.....	.....	.....	.....	3	.....	.....	67081	52685.	33.99	6.578	259.00
.....	.....	.....	.....	.....	.....	2	66373.	52128.	33.63	6.544	257.63
.....	6.5	.....	.....	.....	.....	.....	65490.	51436.	33.18	6.500	255.91
.....	.....	.....	65	.....	.....	.....	65005.	51055.	32.94	6.476	254.96
.....	.....	.....	.....	.....	3	.....	63504.	49876.	32.18	6.401	252.00
1/4	.....	250	.....	.....	.....	.....	62500.	49087.	31.67	6.350	250.00
.....	.....	.....	60	.....	.....	.....	60001.	47124.	30.40	6 222	244.95
.....	.....	.....	.....	4	.....	.....	56644.	44488.	28.70	6 045	238.00
.....	6	.....	.....	.....	.....	.....	55802.	43827.	28.27	6.000	236.23
.....	.....	.....	55	.....	.....	.....	55004.	43200.	27.87	5.957	234.53
15/64	.....	.....	.....	.....	.....	.....	54932.	43143.	27.83	5.952	234.38
.....	.....	.....	.....	.....	4	.....	53824.	42273.	27.27	5.893	232.00
.....	.....	.....	.....	.....	.....	3	52634.	41339.	26.67	5.827	229.42
.....	.....	225	.....	.....	.....	.....	50625.	39761.	25.65	5.715	225.00
.....	.....	.....	50	.....	.....	.....	50001.	39271.	25.34	5.680	223.61
.....	.....	.....	.....	5	.....	.....	48400.	38013.	24.52	5.588	220.00
7/32	.....	.....	.....	.....	.....	.....	47852.	37580.	24.25	5.556	218.75
.....	5.5	.....	.....	.....	.....	.....	46889.	36827.	23.76	5.500	216.54
.....	.....	.....	45	.....	.....	.....	45003.	35346.	22.80	5.388	212.14
.....	.....	.....	.....	.....	5	.....	44914.	35299.	22.77	5.385	212.00
.....	.....	.....	.....	.....	.....	4	41743.	32784.	21.15	5.189	204.31
13/64	.....	.....	.....	.....	.....	.....	41230.	32405.	20.91	5.159	205.13
.....	.....	.....	.....	6	.....	.....	41209.	32365.	20.88	5.156	203.10
.....	.....	200	40	.....	.....	.....	40000.	31416.	20.27	5.080	200.00
.....	5	.....	.....	.....	.....	.....	38752.	30435.	19.63	5.000	196.85
.....	.....	.....	.....	.....	6	.....	36864.	28953.	18.68	4.877	192.00
.....	.....	190	.....	.....	.....	.....	36100.	28350.	18.32	4.826	190.00
.....	4.8	.....	.....	.....	.....	.....	35713.	28055.	18.10	4.800	188.98
3/16	.....	.....	.....	.....	.....	.....	35156.	27610.	17.81	4 762	187.50
.....	.....	.....	35	.....	.....	.....	35002.	27491.	17.44	4.752	187.09
.....	.....	.....	.....	.....	.....	5	33102	25999.	16.77	4.621	181.94
.....	4.6	.....	.....	.....	.....	.....	32799.	25760.	16.62	4 600	181.11
.....	.....	180	.....	7	.....	.....	32400.	25447.	16.42	4.572	180.00
.....	4.5	.....	.....	.....	.....	.....	31389.	24647.	15.90	4.500	177.17
.....	.....	.....	.....	.....	7	.....	30976.	24328.	15.69	4.470	176.00
.....	4.4	.....	.....	.....	.....	.....	30009.	23569.	15.21	4 400	173.23
.....	.....	.....	30	.....	.....	.....	30002.	23563.	15.20	4.400	173.21
11/64	.....	170	.....	.....	.....	.....	29541.	23203.	14.97	4.366	171.88
.....	.....	.....	.....	.....	.....	.....	28900.	22698.	14.64	4.318	170.00
.....	4.2	.....	.....	.....	.....	.....	27343.	21475.	13.85	4.200	165.36
.....	.....	.....	.....	8	.....	.....	27225.	21382.	13 79	4.191	165 00
.....	.....	.....	.....	.....	.....	6	26250.	20618.	13.30	4.115	162.02
.....	.....	160	.....	.....	8	.....	25600.	20106.	12.97	4.064	160.00
.....	.....	.....	25	.....	.....	.....	25002.	19636.	12.67	4.016	158.12
5/32	4	.....	.....	.....	.....	.....	24801.	19479.	12.57	4.000	157.48
.....	.....	.....	.....	.....	.....	.....	24414.	19170.	12 37	3.969	156.25
.....	.....	150	.....	.....	.....	.....	22500.	17671.	11.40	3.810	150.00
.....	3.8	.....	.....	.....	.....	.....	22383.	17579.	11.34	3.800	149.61
.....	.....	.....	.....	9	.....	.....	21904.	17203.	11.10	3.759	148.00
.....	.....	.....	.....	.....	.....	7	20820.	16351.	10.55	3.665	144.29
.....	.....	.....	.....	.....	9	.....	20736.	16286.	10.51	3.658	144.00
.....	3.6	.....	.....	.....	.....	.....	20089.	15778.	10.18	3.600	141.74
.....	.....	.....	20	.....	.....	.....	20002.	15710.	10.14	3.592	141.43
9/64	.....	.....	.....	.....	.....	.....	19776.	15532.	10.02	3.572	140.63
.....	.....	140	.....	.....	.....	.....	19600.	15394.	9.931	3.556	140.00
.....	3.5	.....	.....	.....	.....	.....	18988.	14913	9.621	3.500	137.80
.....	.....	.....	.....	10	.....	.....	17356.	14103.	9.098	3.403	134.00
.....	3 4	.....	.....	.....	.....	.....	17919.	14073.	9.079	3.400	133.86
.....	.....	130	.....	.....	.....	.....	16900.	13273.	8.563	3.302	130.00
.....	.....	.....	.....	.....	.....	8	16510.	12967.	8.365	3.264	128.49
.....	.....	.....	.....	.....	10	.....	16384.	12868.	8.302	3.251	128.00
.....	3.2	.....	.....	.....	.....	.....	15873.	12466	8.042	3.200	125.99
1/8	.....	.....	15	.....	.....	.....	15625.	12270.	7.917	3.175	125.00
.....	.....	.....	.....	.....	.....	.....	15001.	11782.	7.601	3.111	122.48
.....	.....	120	.....	11	.....	.....	14400.	11310.	7.296	3.048	120.00
.....	3	.....	.....	.....	.....	.....	13951.	10954.	7.069	3 000	118.11
.....	.....	.....	.....	.....	11	.....	13456.	10568.	6.818	2.943	116.00
.....	.....	.....	.....	.....	.....	9	13092.	10283.	6.634	2.906	114.42
.....	2.8	.....	.....	.....	.....	.....	12152.	9545.	6.158	2.809	110.24
.....	.....	110	.....	.....	.....	.....	12100.	9503.	6.131	2.794	110.00
.....	.....	.....	12	.....	.....	.....	12 01.	9426.	6.081	2.783	109.55
7/64	.....	.....	.....	.....	.....	.....	11963	9395.	6.061	2.778	109.38
.....	.....	.....	.....	12	.....	.....	11881	9331.	6 020	2.769	109.00
.....	.....	.....	.....	.....	12	.....	10816.	8495.	5.480	2.642	104.00
.....	2.6	.....	.....	.....	.....	.....	10478.	8230.	5.309	2.600	102.36
.....	.....	.....	.....	.....	.....	10	10384.	8155.	5.261	2.588	101.90
.....	.....	100	.....	.....	.....	.....	10000.	7854.	5.067	2.540	100.00
.....	2.5	.....	.....	.....	.....	.....	9688.	7609.	4.909	2.500	98.43
.....	.....	95	.....	13	.....	.....	9025.	7088.	4.573	2.413	95.00
.....	2.4	.....	.....	.....	.....	.....	8928.	7012.	4.524	2.400	94.49
9/32	.....	.....	.....	.....	.....	.....	8789.	9903.	4.453	2.381	93.75

Gauges and Scales.							Cross-Section.			Diameter.	
Vulgar fractions of an inch.	Millimetre scale (diam. in millimetres).	Decimal scale (diam. in mils).	Edison gauge.	Birmingham, or Stubs (Holzapffel) or old English standard gauge. B. W. G.	New British or standard gauge (March 1, 1884).	American or B. & S. gauge.	Circular mils (= d^2) (1 circular mil = .7854 square mils).	Square mils (1 sq. in. = 1,000,000 sq. mils).	Square millimetres (1 sq. mm. = 1550.1 sq. mils).	Millimetres (1 mm. = 39.3708 mils).	Mils (= d) (1 inch = 1,000 mils).
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
.....	.....	.....	.....	.....	13	.....	8464.	6648.	4.289	3.337	92.00
.....	.....	.....	.....	.....	.....	11	8234.	6467.	4.172	3.305	90.74
.....	.....	.....	90	.....	.....	.....	8100.	6362.	4.104	2.286	90.00
.....	.....	.....	.....	8	.....	.....	8001.	6284.	4.054	2.272	89.45
.....	2.2	.....	.....	.....	.....	.....	7502.	5892.	3.801	2.200	86.62
.....	.....	.....	85	.....	.....	.....	7225.	5675.	3.661	2.160	85.00
.....	.....	.....	.....	.....	14	.....	6889.	5411.	3.491	2.108	83.00
.....	.....	.....	.....	.....	.....	12	6530.	5129.	3.309	2 053	80.81
.....	.....	.....	80	.....	.....	.....	6400.	5027.	3.243	2.032	80.00
.....	2.0	.....	.....	.....	14	.....	6200.	4870.	3.142	2.000	78.74
1/64	.....	.....	.....	.....	.....	.....	6104.	4793.	3.093	1.985	78.13
.....	.....	.....	75	.....	.....	.....	5625.	4418.	2.850	1.905	75.00
.....	1.9	.....	.....	.....	.....	.....	5596	4395.	2 835	1.900	74.81
.....	.....	.....	.....	.....	15	13	5184.	4072.	2.627	1.829	72.00
.....	.....	.....	.....	.....	.....	.....	5179.	4067.	2.624	1.828	71.96
.....	1.8	.....	.....	.....	.....	.....	5022.	3944.	2.545	1.800	70.87
.....	.....	.....	5	.....	.....	.....	5001.	3928.	2.534	1.796	70.72
.....	.....	.....	70	.....	.....	.....	4900.	3848.	2.483	1.778	70.00
.....	1.7	.....	.....	.....	.....	.....	4480.	3518.	2.271	1.700	66.93
.....	.....	65	.....	16	.....	.....	4225.	3318.	2.141	1.651	65.00
.....	.....	.....	.....	.....	.....	14	4107.	3225.	2 081	1.628	64.08
.....	.....	.....	.....	.....	16	.....	4096.	3217.	2.076	1.626	64.00
.....	1.6	.....	.....	.....	.....	.....	3968.	3115.	2.011	1.600	62.99
1/16	.....	.....	.....	.....	.....	.....	3906.	3068.	1.979	1.588	62.50
.....	.....	60	.....	.....	.....	.....	3600.	2827.	1.824	1.524	60.00
.....	1.5	.....	.....	.....	.....	.....	3488.	2739.	1.767	1.500	59.06
.....	.....	.....	.....	17	.....	.....	3364.	2642.	1.705	1.473	58.00
.....	.....	.....	.....	.....	.....	15	3257.	2558.	1.650	1 450	57.07
.....	.....	.....	.....	.....	17	.....	3136.	2463.	1.589	1.422	56.00
.....	1.4	.....	.....	.....	.....	.....	3038.	2384.	1.539	1.400	55.12
.....	.....	.....	55	.....	.....	.....	3025.	2376.	1.533	1.397	55 00
.....	.....	.....	.....	3	.....	.....	3001.	2357.	1.521	1.391	54.78
.....	1.3	.....	.....	.....	.....	.....	2620.	2057.	1.327	1.300	51.18
.....	.....	.....	.....	.....	.....	16	2583.	2029.	1.309	1.291	50.82
.....	.....	.....	50	.....	.....	.....	2500.	1964.	1.267	1.270	50.00
1/32	.....	.....	.....	.....	.....	.....	2401.	1886.	1.217	1.245	49.00
.....	.....	.....	.....	.....	18	.....	2304.	1810.	1.167	1.219	48.00
.....	1 2	.....	.....	.....	.....	.....	2232.	1753.	1.131	1.200	47.25
3/64	.....	.....	.....	.....	.....	.....	2197.	1726.	1.113	1.191	46.88
.....	.....	.....	.....	.....	.....	17	2048.	1609.	1.038	1.150	45.26
.....	.....	.....	45	.....	.....	.....	2025.	1590.	1.026	1.143	45.00
.....	1.1	.....	.....	.....	.....	.....	1875.	1473.	.9509	1.100	43.31
.....	.....	.....	.....	.....	19	.....	1764.	1385.	.8958	1.067	42.00
.....	.....	.....	.....	.....	.....	18	1624.	1276.	.8230	1.024	40.30
.....	.....	.....	40	.....	.....	.....	1600.	1257.	.8107	1.016	40.00
.....	1.0	.....	.....	.....	20	.....	1550.	1217.	.7854	1.000	39.37
.....	.....	.....	.....	.....	.....	19	1296.	1018.	.6567	.9144	36.00
.....	.....	.....	.....	.....	.....	.....	1288.	1012.	.6527	.9116	35.89
.....	.9	.....	.....	.....	.....	.....	1256.	985.9	.6362	.9000	35.43
.....	.....	35	.....	20	.....	.....	1225	962.1	.6207	.8890	35.00
.....	.....	.....	.....	21	21	.....	1024.	804.2	.5188	.8128	32.00
.....	.8	.....	.....	.....	.....	20	1022.	802.3	.5176	.8118	31.96
.....	.....	.....	.....	.....	.....	.....	992 0	779 3	.5027	.8000	31.50
1/32	.....	.....	.....	.....	.....	.....	976.6	767.0	.4948	.7937	31.25
.....	.....	30	.....	.....	.....	.....	900.0	706.9	.4560	.7620	30.00
.....	.....	.....	.....	.....	.....	21	810.1	636.3	.4105	.7229	28.46
.....	.....	28	.....	22	22	.....	784.0	615.8	.3972	.7112	28.00
.....	7	.....	.....	.....	.....	.....	759.5	596.5	.3848	.7000	27.56
.....	.....	26	.....	.....	.....	.....	676.0	530.9	.3425	.6604	26.00
.....	.....	.....	.....	.....	.....	22	642 5	504 6	.3255	.6438	25.35
.....	.....	25	.....	23	.....	.....	625.0	490.9	.3167	.6350	25.00
.....	.....	24	.....	.....	23	.....	576.0	452.4	.2919	.6096	24.00
.....	.6	.....	.....	.....	.....	.....	558.0	438.3	.2827	.6000	23.62
.....	.....	.....	.....	.....	.....	23	509.5	400.2	.2581	.5753	22.57
.....	.....	22	.....	24	24	.....	484.0	380.1	.2452	.5588	22.00
.....	.....	.....	.....	.....	.....	24	404.1	317.3	.2047	.5106	20.10
.....	.....	20	.....	25	25	.....	400.0	314.2	.2027	.5080	20.00
.....	.5	.....	.....	.....	.....	.....	387.5	304.4	.1963	.5000	19.69
.....	.....	19	.....	.....	.....	.....	361.0	283 5	.1832	.4826	19.00
.....	.....	18	.....	26	26	.....	324.0	254.5	.1642	.4572	18.00
.....	.....	.....	.....	.....	.....	25	320.4	251.7	.1624	.4547	17.90
.....	.45	.....	.....	.....	.....	.....	313.9	246.5	.1590	.4500	17.72
.....	.....	17	.....	.....	.....	.....	289.0	227.0	.1464	.4318	17.00
.....	.....	.....	.....	.....	27	.....	269.0	211.2	.1363	.4166	16.40
.....	.....	16	.....	27	.....	.....	256.0	201.1	.1297	.4064	16.00
.....	.....	.....	.....	.....	.....	26	254.1	199.6	.1288	.4049	15.94
.....	.4	.....	.....	.....	.....	.....	248.0	194.8	.1257	.4000	15.75
1/64	.....	.....	.....	.....	.....	.....	244.1	191.8	.1237	.5969	15.63
.....	.....	15	.....	.....	.....	.....	225.0	176.7	.1140	.3810	15.00
.....	.....	.....	.....	.....	28	.....	219.0	172.0	.1110	.3759	14.80
.....	.....	.....	.....	.....	.....	.....	201.5	158.3	.1021	.3606	14.20
.....	.....	14	.....	28	.....	27	196.0	153.9	.09931	.3556	14.00
.....	.35	.....	.....	.....	.....	.....	189.9	149.1	.09631	.3500	13.78
.....	.....	.....	.....	.....	29	.....	185.0	145.3	.09372	.3454	13.60
.....	.....	13	.....	29	.....	.....	169.0	132.7	.08563	.3302	13.00
.....	.....	.....	.....	.....	.....	28	159.8	125.5	.08097	.3211	12.64
.....	.....	.....	.....	.....	30	.....	153.8	120.8	.07792	.3150	12 40
.....	.....	12	.....	30	.....	.....	144.0	113.1	.07296	.3048	12.00
.....	.3	.....	.....	.....	.....	.....	139.5	109.5	.07069	.3000	11 81
.....	.....	.....	.....	.....	31	.....	134.6	105.7	.06818	.2946	11.60
.....	.....	.....	.....	.....	.....	29	126.7	99.53	.06421	.2859	11.26
.....	.28	.....	.....	.....	.....	.....	121.5	95.45	.06158	.2800	11.02
.....	.....	11	.....	.....	.....	.....	121.0	95.03	.06087	.2794	11.00
.....	.....	.....	.....	.....	32	.....	116.6	91.61	.05910	.2743	10.80
.....	.25	.....	.....	.....	.....	.....	104 8	82.30	.05309	.2600	10.24
.....	.....	.....	.....	.....	.....	30	100.5	78.94	.05092	.2546	10.03
.....	.....	10	.....	31	33	.....	100.0	78.54	.05067	.2540	10.00
.....	.24	.....	.....	.....	.....	.....	89.28	70.12	.04524	.2400	9 449
.....	.....	.....	.....	.....	34	.....	84.64	66.48	.04289	.2337	9 200
.....	.....	9	.....	32	.....	.....	81.00	63.62	.04104	.2286	9.000
.....	.22	.....	.....	.....	.....	31	79.70	62.60	.04039	.2268	8.928
.....	.....	.....	.....	.....	35	.....	75.02	58.90	.03801	.2200	8.662
.....	.....	.....	.....	.....	.....	.....	70.56	55.42	.03575	.2134	8.400
.....	.....	8	.....	33	.....	.....	64.00	50.27	.03213	.2032	8.000
.....	.....	.....	.....	.....	.....	32	63.20	49.64	.03203	.2019	7.950
.....	.20	.....	.....	.....	.....	.....	62.00	48 70	.03142	.2000	7 874
.....	.....	.....	.....	.....	36	.....	57.76	45.36	.02926	.1930	7.600
.....	.18	.....	.....	..

The Inventors of the Telegraph and Telephone.*

BY PROF. THOMAS GRAY.

To telegraph means literally to write at a distance, but that is not the popular meaning of the term. When we speak of a system of telegraphy, we have usually in mind simply a systematic method of conveying intelligence to a distance. Taken in this sense, there are a large number of different kinds of telegraphs, such as hydraulic, pneumatic, wire, flag, semaphore, trumpet call, gun fire, flash light, beacon fire, etc., etc., besides the one which is now usually associated with the name, the electric telegraph. Any means of conveying intelligence to a distance which the human voice will not reach is spoken of as a telegraph.

One of the earliest systems of telegraphy was introduced about the middle of the seventeenth century by order of the Duke of York (afterwards James II. of England), then Admiral of the English fleet. This was the beginning of the flag telegraph, almost universally used between ships at sea, and was originated for the purpose of directing the movements of the fleet. In 1694 Dr. Hooke proposed to telegraph by means of objects of different shapes hung on high poles. A century later the semaphore of M. Chappe was adopted by the French government for the same purpose.

Generally speaking, these early forms of telegraphy, of which there were quite a number of kinds used, were adopted and perfected during time of war. Undoubtedly war has been a large factor in furthering the development of our modern telegraphs, and in this way at least may be said to push forward the march of civilization. Some of these forms of telegraph are still used, as, for example, the semaphore for railway signals, the bell worked by wire for communication between the bridge and engine-room in steamships, and flag signals for communication between ships at sea. The chief interest of these early forms, however, in connection with our present subject, is an illustration of the importance which telegraphy has at all times been recognized to have. The telegraph of to-day is almost entirely electrical, and, in its present form, it is of comparatively recent growth. It may, however, be well to glance very briefly at the early attempts which were made to use electricity for this purpose, and to note how persistently the possibility of making this application was brought forward as each distinct advance was made in the science of electricity and magnetism.

In the year 1617 we find an allusion in one of Strada's "Prolusions Academicæ" to the belief that there existed a sympathy between needles which had been touched by a species of loadstone, which, when they were freely pivoted, caused them to set in the same direction. Thus, he says, two of the needles may be used to convey intelligence to any distance instantaneously, because if they be mounted on a card marked with letters and are turned so as to point to any letter the other will immediately do so also. Again, in 1632, Galileo, in one of his dialogues, puts in the mouth of one of the speakers a reference to a secret art by means of which, through the sympathy of magnetic needles, it is possible to converse through a distance of several thousand miles. A similar suggestion is made by the Abbe Barthélémy, published in 1788, entitled "Voyage du Jeune Anacharsis." So far this may be said to be mere fable, as it is hardly possible to believe that such a proposal would even then be made in good faith. They bring out, however, what may be looked upon as an indication of the popular idea at that time as to the possibilities of magnetism. We have occasionally at the present day propositions as to the powers of electricity which are equally ideal.

The discovery of Stephen Gray in 1729 that the electrical influence produced by friction could be transmitted to a distance through a "non-electric" material is probably the first of direct interest in connection with telegraphy. We have, as a result of this discovery, the proposal, in 1753, of a telegraph by Charles Morrison, of Renfrew, Scotland, in which a number of separate conductors were to be used for the purpose of spelling out the message by putting them in contact, with balls placed over letters printed on light material which could be lifted by the electrified balls. Several modifications were proposed, and are of considerable interest; mainly, the possibility of causing the electrified balls by their attraction to ring bells and then give our acoustic telegraph. A similar system was proposed by Joseph Bozolas, a Jesuit priest, in the year 1767, and seven years later Lesage modified the idea by the proposal to use pith ball electroscopes to indicate the signals. This telegraph was actually constructed on an experimental scale. In 1787 Lomond simplified the pith ball telegraph to one wire and one electroscope, by means of which he was able to keep up a conversation with his wife in a distant apartment of the house. To Lomond then appears to be due the first proposal to use an alphabet of motions. A similar one-line telegraph was proposed in the same year by Betanchcourt. An ingenious idea was proposed in 1794 by Rousser, who used 26 wires, each wire being connected to a strip of tinfoil, small breaks in which formed a letter. The letter was to be made visible by an electric spark. The illumination of patterns in this way has continued to be a favorite class-room illustration to the present day.

In the following year we find another proposal of an alphabet of signals, made in this case by M. Cavallo. One wire was to be used, and the alphabet was to be made up of sparks and pauses in various combinations. Cavallo also proposed to use an alarm to call attention. This was to consist of an explosion of a mixture of oxygen and hydrogen, or of gunpowder by means of the electric spark. Another proposition of a similar character, but of which the particulars seem to be unknown, was proposed by Salva in 1796. After this there appears to be no record of the application of frictional electricity to telegraphic purposes till 1816, when Ronalds' experiments were made at Hammersmith. In this telegraph two clocks were used in conjunction with one line wire and a pith ball electroscope at each end. On the second hand arbor of each clock a light dial was placed on which the letters of the alphabet were printed. A screen was placed in front of the dial, through a hole in which the letters could be seen. At a time when the proper letter came in front of the screen at the sending end, a signal was sent, and the letter opposite the hole in the screen at the receiving end was then read.

It will be observed that a considerable amount of energy was spent on the electric telegraph, and some very feasible methods were proposed before electrical science had passed the stage of the frictional generation of electrical force.

In the year 1767 an important observation was made. It was noticed that when a plate of one metal was placed on one side of the tongue, and a plate of another metal was placed on the other, a curious sensation was felt when the metals were allowed to touch outside the tongue. The observer failed to find the explanation, and nothing more was done until the well-known experiments of Galvani gave an impetus to the subject, which resulted in the discovery of the galvanic or voltaic pile by Volta. Shortly afterward an attempt to close the circuit of a voltaic pile by a drop of water led Nicholson and Carlisle to the discovery that the galvanic current decomposed water. Here was a new means of giving signals, and eight years later we find a proposal by Sömmering to make use of the evolution of gas in a series of tubes connected to a distant station by means of conduction wires for the transmission of intelligence. A call signal was to be obtained by causing the liberation of gas to operate an alarm. A similar idea to that of Sömmering suggested itself about the same time to Prof. Coxe, of Pennsylvania, who, however, seems not to have worked it out to any extent. The next important discovery which influenced telegraphy was made by Romagnosi, of Trent, in 1805, but does not seem to have become widely known until rediscovered by Oersted, of Copenhagen, in 1819. This discovery was the deflection of the magnetic needle when a wire conveying a current was brought near it, the wire being approximately parallel to the length of the needle. In 1820 Schweigger discovered that if the wire be bent round the needle several times, the force with which the needle is deflected is increased. These two discoveries formed the foundation for the galvanometers, since so much used in electrical appliances and measurements. One of the most extensive applications has been to telegraphy.

Ampère in 1820 was the first to point out the application of the galvanoscope and voltaic battery to telegraphy, but proposed to use as many wires as letters or signs to be transmitted. A modification of this invention was made by Ritchie, who constructed an experimental telegraph, in which the letters of the alphabet were arranged behind a set of light screens, which were drawn aside by the current, thus exposing the letters to view. This telegraph was exhibited some years later by Mr. Alexander, of Edinburgh, and cousisted of a keyboard of 30 keys representing 26 letters, three punctuation marks, and an asterisk for indicating the end of a word. These keys were connected to as many wires operating screens as above described. The return current was common to all.

In 1832 Schilling invented his five-needle telegraph, which was subsequently modified to a single needle. Two wires were used and an alphabet of motions made use of, much in the same way as is still carried out by the single needle system. A telegraph on Schilling's plan was used in the following year by Gauss and Weber in connection with their electrical researches and the regulation of the clocks. Schilling, however, died before any practical development of the telegraph was made. It seems probable, however, that the idea of the needle telegraph, so long used successfully in Europe, and particularly in England by Cooke and Wheatstone, was devised by Schilling.

Steinheil was the next to enter the field of telegraphic invention, and he appears to have done so at the suggestion of Gauss, who saw great possibilities of its development. Steinheil invented his telegraph in 1837. He constructed a line several miles in length at Munich and fitted it with recording apparatus of an ingenious kind. A flat coil or multiplier was made, and inside the coil two magnetic needles were fixed so as to form continuations of each other, one end of each being at the centre of the coil. These magnets carried at their central ends recording pens. A band of paper was carried past these pens, and the record was obtained by causing the pens to strike the paper and leave dots at the point of contact. Reverse currents were used, one pen answering to a current in one direction and the other to currents in the other direction. The system practically amounted to a double-needle system worked by one circuit and one galvanoscope.

The telegraphs of Gauss and Weber, and the developments of them by Steinheil, have special interest, from the fact that they were the first telegraphs which used what we now call induced currents. The currents were produced by the relative motion of a coil of wire and a magnet. This was an application of the discovery of Faraday and Henry, that the motion of a magnet in the neighborhood of a circuit produced transient currents in the circuit, a discovery which has had wonderful effects in the development of modern dynamo-electric appliances.

Another discovery of great importance and interest, which we owe to Steinheil, is the earth circuit. While experimenting with a view of using the rail of a railway as one of the wires of his circuit, he discovered that the earth itself might be used for one-half of the circuit, and he removed one of his wires, substituting plates buried in the earth. This method is still practiced, and the discovery has proved one of the very greatest importance.

Previous to the date which we have now reached another epoch-making discovery had been made in electricity and magnetism. This was the magnetizing influence of the current. The discovery of Oersted was followed up by Ampère in a long series of experiments, in the course of which he found the mutual attraction and repulsion of wires carrying currents; the fact that the voltaic element itself acted as a magnet like any other part of the circuit, and also that a spiral part of a circuit would magnetize steel needles. M. Arago also in the same year discovered that the wire conveying the current attracted iron filings in much the same way as a magnet does. In 1824 Barlow investigated the law of variation of the magnetic force at different distances from the wire. In 1825 Sturgeon discovered that when a bar of soft iron is surrounded by a helix, and a current is sent through the helix, it is temporarily magnetized. We see from these leading facts that in the 12 years preceding Oersted's discovery progress in the knowledge of electricity and electromagnetism in the directions important for telegraphic application was very great, and we shall see that this knowledge very quickly bore fruit.

A copy of Schilling's telegraphic apparatus, exhibited by Prof. Muncke at Heidelberg, in 1836, gave the idea of the electric telegraph to Cooke. Cooke immediately set to work to construct a telegraph on a similar plan, and worked out several schemes which he had partially succeeded in introducing on the railway systems of England. Through some difficulty with an electromagnetic arrangement he was led to consult Prof. Wheatstone, and a partnership followed soon, which led the latter to devote considerable attention to the subject. The result has been the production of a large variety of apparatus of great value and ingenuity.

The first to prepare a recording telegraph seems to have been Prof. Morse, of New York. This invention dates back to 1832, according to a considerable amount of evidence brought forward by Morse, and a rough model existed as early as 1835. In this telegraph an electromagnet is used as the motive force, and Morse claimed not only the first recording telegraph, but also the first application of the electromagnet in telegraphing. There can be no doubt, however, but that the credit of having first used the electromagnet for telegraphic purposes is due to Prof. Henry, then a teacher in the Albany Academy. To Prof. Henry belongs not only the credit of using the electromagnet for this purpose, but also that of having developed the discovery of Sturgeon to such an extent as to enable any one to make a magnet which would be of service as a receiver on a long telegraph line.

Another important invention in this connection has to be given to Henry. While experimenting on the electromagnet he turned his attention to the construction of the electromagnetic engine, and in connection with it contrived a method of closing the circuit of the engine from a distance by means of an auxiliary circuit and an electromagnet. This is the electromagnetic relay, afterwards re-invented by Morse and now used on nearly all important telegraph circuits. We see therefore that the credit of the application of the electromagnet to telegraphic purposes was of American origin, but that it was not first, as is popularly believed, made by Morse. The conception, however, of a telegraph by Morse, whether it originated with him or not, has proved of great value. He, in conjunction with Vail, worked it out on a practical scale, perfected details, invented the Morse alphabet, and last, though not least, succeeded after a great amount of trouble and many disappointments in obtaining the support of Congress toward making it a national enterprise. Previous to the year 1842, when Congress passed an appropriation for experiments with the electric telegraph, the application of electricity to this purpose had gone practically beyond the experimental stage in Europe, the single and double instruments being used for indicating the signals. It has been long popularly believed in this country that Morse invented the electric telegraph. In the same way it was long popularly believed in England that Wheatstone did so, and similarly in other countries. It will be seen, however, from the brief sketch here given, that the invention of the electric telegraph does not belong to any one man or any one country. It has grown with scientific knowledge, and forms as it stands to-day one of the best illustrations we have of the value of purely experimental investigations.

From this time until the question of using one wire for

* A paper read at the Centennial Celebration of the Establishment of the American Patent System.

more than one message at one time and the problems of submarine telegraphy arose, no new scientific principle was required. Methods of recording and indicating signals multiplied, and mechanical contrivances of great beauty were invented for many of these, but the discoveries of Volta, of Oersted and Schwiegger, of Nicholson and Carlisle, of Sturgeon, and of Faraday and Henry were enough, from the electrical standpoint, for them all. Of the different methods which were invented in the next quarter of the century, we may take the chemical telegraphs of Davy, Bain and others; the dial telegraph of Wheatstone, Breguet, Froment, Siemens, Chester, Koemer; the automatic telegraphs of Bain, Siemens and Halske, Garnier, Humaston, Wheatstone; the copying telegraphs of Bakewell, and the pantelegraph of Casselli; and the type printing telegraphs of Vail, Wheatstone, House and Hughes. In more recent times many of these inventors and a host of others, including in this country the names of Bell, Calahan, Delany, Edison, Gray, Laws, Little, Park, Phelps, Prescott, Smith, Stearns, and many more, have added important contributions to the subject. The type printing instruments produced by several of these inventors are triumphs of mechanical ingenuity which find few equals in any branch of mechanical industry.

As distinct from the instrumental improvement in telegraphy, the next important advance was multiple transmission. A solution of the problem of transmitting simultaneously from both ends of the same line wire was first attempted in 1853 by Gintl, of Vienna, and again by Frischen and Siemens and Halske. The solutions proposed by these inventors were mechanically sufficient for the purpose, but they overlooked an important factor which had not before been considered important in land line telegraphs—the electrostatic capacity of the line. This difficulty was first successfully overcome by Stearns, of Boston, at the close of 1871, and since that time duplex working has become quite common. The application of Stearns' method to submarine telegraphs involved peculiar difficulties, on account of the very large capacity of the line, and, in the more important cables, the great length of the circuit. The credit of having completely overcome these difficulties for submarine cables is mainly due to Dr. Muirhead, of London. The chief workers in this field were: Gintl, Frischen, Siemens and Halske, Preece, Farmer, Nystrom, Maron, Winter, Stearns and Muirhead. The problem of how to send two messages in the same direction being solved, the transmission of four messages simultaneously over the same wires was attacked. This was first proposed by Stark, of Vienna, in 1855, and subsequently worked at by Bosscha, Kramer, Mason, Schaak, and others. The first to obtain satisfactory results was Edison, who invented his method in 1874. Successful systems of quadruplex have since been invented by Smith and Prescott jointly.

Another system of multiple transmission was proposed by Moses G. Farmer, of Salem, Mass., in 1852, in which, by a commutating arrangement, the main line wire was put, in rapid succession, in contact with a series of branch wires, by proper connection at the sending station and two communicators worked in unison. It was then proposed to divide the transmitting capacity of the main line wire among a number of branch wires, so that the messages might go over all of these at the same time. A similar arrangement was proposed by Meyer, and shown in operation at the Vienna exhibition in 1873. The same principle is adopted in Delany's telegraph, devised a few years ago and in successful operation in various parts of the world.

Distinct from these is the harmonic telegraph of Gray, Edison and Bell. In this system, which has been completely worked out by Gray, any number of messages may be sent simultaneously without reference to speed of transmission. In principle the method consists in causing a number of vibrating reeds of different pitch at one end to produce vibrations in a corresponding set of reeds at the other end of the line, each of the receiving reeds picking out the vibration which has the same pitch as that of its own vibration.

Although the mere extension of telegraphs from land to submarine lines can hardly be called an invention, yet very many new problems presented themselves for solution in this extension. Many of these problems were of a more scientific character than those presented in the developments which had been in progress, and consequently taxed the knowledge then existing of the laws of electricity much more severely. It was very soon discovered, for example, that the rate at which signals would be transmitted and the battery power, or other electromotive power necessary to effect the transmission, did not, as in land lines, depend almost entirely on the size of and length of the conductor. The electrostatic capacity of the line immediately began to play an important part, and signals were found not to be so instantaneously transmitted as they were on existing lines. Again, there was no opportunity of using relays so as to effectually shorten the longer lines.

Such difficulties as these, combined with the very evident mechanical difficulties of manufacturing and submerging a cable in deep water, were, to say the least, discouraging. Experiments in short lengths in the English Channel and elsewhere proving successful, faith in the possibility of longer cables grew, and very soon, through the enterprise of a few American and English business men, an attempt was made to lay a cable across the Atlantic. The history of that undertaking and its various failures are almost common knowledge, but perseverance conquered all the difficulties, and to-day very little is thought of difficulty when a long cable is proposed.

The laying of long cables brought out the fact that, as had been anticipated, existing telegraphic apparatus was not of great enough sensibility to render rapid signaling possible. This difficulty was almost immediately met by the mirror galvanoscopic receiver of Thomson, followed some years later by his siphon recorder, which is undoubtedly by far the most sensitive recording telegraph known. Improvements in methods of working cables soon followed, among which in the early days probably the most notable is the introduction of condensers between the ends of the cable and the earth by Varley. The duplexing of cables has already been referred to, but it is somewhat curious to note that, although the electricians interested in cables were familiar as early as 1856, and perhaps earlier, with the difficulties which had prevented success on land lines, no one seems to have thought of applying the remedy. As early as 1858 a patent was taken out by Thomson, in which he proposed to overcome this difficulty of duplexing a cable by a mechanical arrangement for varying the compensating currents at the same rate that the signaling current varies. He has since said that he did not propose the use of condensers, because a means of producing a sufficiently good cable was not then known.

The invention of the telephone constitutes one of the greatest advances that have been made in telegraphic communication. This is an acoustic telegraph which has the very important merit that the audible signals are spoken words, and hence the instruments can be used by any one who can hear and speak.

It is well known that sound is transmitted through the air from speaker to hearer by means of waves, condensation and rarefication, which affect the drum of the ear. Wheatstone, as early as 1831, showed that these waves could be transmitted from one place to another at a moderate distance through wooden rods, and afterward conveyed to the ear by the vibrations given to the air by the end of the rod. Similarly, vibrations given to one diaphragm to produce the corresponding vibrations in another diaphragm at a distance by means of electric currents was the problem of the electric telephone. The first to propose this appears to have been Charles Bourseul, who, in 1854, suggested the use of two plates, one at the transmitting station, which, by the varying pressure of the air due to the sound waves, would open and close an electric circuit, while the other was to be acted on at the receiving station by an electromagnet, through which the electric currents passed.

In 1861 Philip Reis, of Friedrichsdorf, proposed, in a lecture delivered before the Physical Society of Frankfort, to use an instrument which he called a telephone, for the production at a distance of music and human speech. The apparatus consisted of a flexible membrane, forming one side of a box, with which, by means of a mouthpiece, the sounds could be directed. This instrument was made to open and close an electric circuit at each vibration. At the receiving end an electromagnet consisting of a thin rod of iron surrounded by a coil was placed. The successive interruption and closing of the electric circuits was in accordance with a discovery made by Dr. Page, of Salem, Mass., in 1837. This method could not be successful for speaking, for the simple reason that speech has more characteristics than pitch, and was only partially successful for musical sounds. To produce not only corresponding vibrations, but also loudness and quality of the sounds, evidently required a transmitter and receiver which did not depend for its action on such interruptions of the current, but which varied the current in a pulsatory manner similar to the variations of pressure on the diaphragm due to the waves. Such an apparatus of a very perfect type was produced by Graham Bell in 1876, who, in the description of his apparatus given in his patents and elsewhere, shows that he thoroughly understood what had to be done. We all know that the instrument which he produced did it. Since the publication of Bell's invention a great many modifications have been produced. Most of them, however, have been held to be similar in principle to Bell's. One field of investigation has, however, been fruitful of improvement. In the original patent of Bell, and in a caveat filed almost simultaneously by Gray, it is pointed out that the variations of the current may be produced by causing the vibrations of the diaphragm to vary the resistance of the circuits. This idea has proved of great value in increasing the loudness of the sounds given out by the Bell telephone used as a receiver. A great many forms of these "microphone" transmitters have been invented. Among those who have made important contributions to this subject we may mention Berliner, Edison, Gray, Blake, Gower and Hunning.

Another form of telephone has been proposed by Prof. Dolbear. In this telephone system one diaphragm of the receiver is made to form one plate of an electric condenser, and the varying force on this plate due to the fluctuations of the charge causes it to vibrate in response to the varying electromotive force produced by the transmitter. This condenser telephone can evidently be used either as a transmitter or receiver.

Another interesting discovery in this subject should be mentioned, namely, the transmission of speech from one place to another by variations in a beam of radiant heat or light. This is based on the discovery of the variation of the electric resistance of selenium when exposed to light or radiant heat. The experiments of Bell and Sumner Tainter have shown that, if a beam of light be reflected from a mirror to a bar of selenium which is in the circuit of a telephone and battery, the telephone will repeat words spoken to the mirror.

The Incandescent Lamp.*

BY THOS. G. GRIER.

Incandescent lighting is now merging into a second decade of commercial life, and any neglect on the part of the electrical fraternity to fully understand the importance which the incandescent lamp plays in this growing industry is suicidal to their interests. The subject is entirely too large to treat comprehensively in a limited article, but a few points will be brought forward that, it is hoped, will promote discussion and bring forth valuable information from the members of the club.

Though ten years have hardly passed since incandescent lighting has been an acknowledged possibility, the birth of the lamp has been recorded for nearly half a century. Platinum wire heated to incandescence seems to have been the earliest form of the incandescent lamp, and was experimented with even as recently as 1885. In 1845 we read of experiments with carbon sticks and pencils, inclosed in glass globes, that were either filled with some non-active gas or had the air exhausted and the carbon surrounded by a vacuum.

The march of invention at last, in 1879, reached a point at which the public was assured that a new era of artificial illumination would be upon them, and so authoritative was this assurance that gas stocks all over the country declined in value. It was not, however, until the year 1880 that any definite information as to the electrical properties of the incandescent lamp was determined, and in 1881 incandescent lighting was no longer a laboratory phenomena, but was merging into an industry, the proportions of which at the present day are hardly realized.

The Franklin Institute, at Philadelphia, in view of the great advance in the application of electrical science to commercial uses, discussed the advisability of holding an electrical exhibit, and in the fall of 1884 the desire and anticipation of the members of the institute were accomplished.

The limited knowledge and the absence of any reliable data on incandescent lamps led the institute to invite the manufacturers of incandescent lamps to place samples of their lamps in the hands of an impartial committee of experts for a comparative test. These results were published in September, 1885, and from the official report a few results have been compiled.

Five different manufacturers submitted their lamps, some submitting several batches of different voltages. The lamps were tested for duration or life, and before placing on test their initial efficiency per spherical candle-power was determined.

The following tabulated data is of six sets of lamps:

Make.	Average life.	Voltage.	Initial efficiency per spherical c. p.	Loss in c. p.
Weston	454 hours	111	3.63	50 per ct.
White	274 "	50	4.08	7 "
Woodhouse & Rawson	290 "	555	5.56	33 "
Stanley	430 "	96	3.92	37 "
Stanley	294 "	44	3.45	34 "
Edison	1,026 "	97.9	4.48	35 "

From the results as given in the table it will be seen that the greatest depreciation in candle power was 50 per cent. and the least 33 per cent. This, however, cannot be taken for any comparison, as the life of the lamps showed such a great disparity. The depreciation of the Edison lamps, which proved superior in the test, was 35 per cent. These results are looked upon to-day as of little practical value except as historical record, but they have taught us that a lamp is a delicate thing to handle, and whether a lamp is a lamp of value depends on many circumstances. These results were a valuable round added to the ladder of knowledge, and it is hoped that experiments of a like nature, yet of more practical value, will be made in the near future for the benefit of the incandescent lighting plants and the men interested in incandescent lighting.

Since 1884 many other makes of lamps have come on the market, and knowledge gained by experience has both improved the quality of the lamps and cheapened the process of manufacturing. (In 1884 lamps were advertised 16 c. p., $3; to-day from 40 cents to 60 cents may be taken as an average price.)

Six years now have passed since the Franklin Institute experiments, and we are almost as much in the dark as in the earlier days of the industry. The question of life seems to be the most important factor to be considered from the central-station point of view, and to meet this desire various manufacturers frequently guarantee the average life of their lamps. Those guaranteeing the longest life, and, at the same time, proving their guarantee, usually get the majority of the business.

From time to time we hear of some remarkable lamp whose life has run into the thousands of hours, and often have I heard the veracity of a man's statement questioned

*A paper read before the Chicago Electric Club, April 20, 1891.

when he has given some facts in regard to long lived lamps. In my own experience I have known of a lamp burning from seven to ten hours a day for six years, which would mean a minimum life of 13,000 hours. Yet to make this statement off-hand to the general public, and even to the electrical fraternity, it would be received with doubt. There is not, however, the least trouble in making an incandescent lamp for any desired life. The life of a lamp depends upon the efficiency at which it is burned.

John W. Howell, in 1888, published a statement based upon the experiments of the Edison Company, which covered five years of time, and the use of thousands of lamps. In this statement he says the life of a lamp burned at two watts efficiency was practically zero; at three watts per candle it was 1,000 hours; at four and three-fourths watts per candle power it was 16,000 hours. This at once shows that the question of life is merely a question of circumstances, and may or may not be advantageous. He also stated in the same paper that the candle power of any lamp depends upon the efficiency at which it is burned. An Edison lamp gave five candle-power when run at 6.7 watts per candle power, and when the efficiency was increased to 2.66 watts the candle power was increased to twenty, this variation depending upon the electromotive force operating the lamps. These statements show that the Edison lamps follow a law. All makes of lamps follow this same general law, each having its own especial curve, and it is this curve that gives the average quality of lamp.

The object of an incandescent lighting station is to produce light. It is necessary to develop electrical energy, but it is the lamp that transforms this electrical energy into light. The electrical energy represents the dollars of the investor and operations of the station, and it is most important that it should be used with the greatest economy to obtain proper return for the investor. This must needs bring into the question the lamp used; the life, the cost, and the efficiency being the three considerations.

To bring the matter to a point at once we will assume conditions which are perfectly feasible and within the bounds of possibility. First, we will consider that a lamp burning at 4½ watts efficiency will depreciate but a minimum for the first 1,000 hours. We will consider this lamp and the cost of operating it. A lamp at 4½ watts efficiency and 16 c p., burning for 1,000 hours, would require a total expenditure of electrical energy of 72,000 watt hours. This, at one cent for 50 watt hours, would be $14.40 for the current, and adding 50 cents for the cost of the lamp would make a total cost of $14.90 for burning this lamp 1,000 hours. The efficiency of another lamp is 3½ watts per candle power. We will not say how many lamps will have to be replaced in the 1,000 hours, but just assume that the efficiency of 3½ watts per candle power is maintained throughout the 1,000 hours. The total expenditure of energy on this basis will be 56,000 watt hours, which will cost, at the rate of one cent for 50 watt hours, $11.20. Adding 50 cents to this for the cost of the first lamp makes it $11.70, leaving a difference in favor of the 3½ watt lamp of $3.20, which of course will have to be used to a certain extent in replacing the lamps; but, allowing that a 3½ watt lamp will maintain its efficiency for 333 hours, we will merely have to pay $1.00 additional for replacing lamps and have a net saving of $2.20. This, though an assumption, is not distorted, for lamps from 3½ to 4½ watts efficiency are on the market, and yet many a station is being operated with lamps of a worse efficiency than 4½ watts, and they wonder why it is that their dividends are smaller than those of other plants. It is the incandescent lamp that will make or break the dividend-paying record of the central station, and it should be considered with the utmost care. However, the London *Electrical Review* has published some facts which will be analyzed as this assumption has been, and will show immediately the advisability of maintaining efficient lamps on a circuit even though their life be short.

The facts published by the London *Electrical Review* were in an account of a test on Edison Swan lamps and the results were presented in tabulated form, giving the initial candle power, the initial efficiency and the total watts used on the lamp. A test of 1,000 hours duration was started, and at the end of each 100 hours observations were made as to the candle power and the total energy, the efficiency of the lamps being computed and placed in the table. This table is presented to you in this article, with the deductions drawn from the data as given. The first four columns of the data are as furnished by the *Electrical Review*, and the other columns are deductions drawn from the first four columns.

TABLE B.

Hours.	C. p.	Watts per c. p.	Total watts.	Average of each 100 hours.		Cost figured on the basis of 1 cent for 50 watt hours.	
				Average c. p.	Average total watts.	Cost for each 100 hours.	Cost of 16 c. p. at each 100 hours.
0	19.3	3.34	64.46	.....	.....	.....	.....
100	18.8	3.45	64.86	19.05	64.66	$1.293	1.08
200	17.2	3.79	65.19	18.00	65.03	1.300	1.16
300	15.6	4.10	63.96	16.40	64.57	1.297	1.25
400	15.2	4.17	63.38	15.40	63.67	1.270	1.32
500	14.8	4.29	63.49	15.00	63.44	1.268	1.35
600	14.4	4.38	63.07	14.60	63.28	1.264	1.38
700	14.1	4.50	63.45	14.25	63.26	1.265	1.42
800	13.3	4.98	62.24	13.70	62.85	1.257	1.47
900	12.4	4.90	60.76	12.85	61.50	1.230	1.53
1,000	12.0	5.00	61.00	12.20	60.38	1.207	1.58

Column 7 shows what the customer pays each 100 hours for the lamp he is using. Column 8 shows what he pays for each 16 c. p. of light he gets for each of the 100 hours. These figures are computed upon the average of the observations, that is, for the first 100 hours the average candle power produced is taken, and so on, for each succeeding 100 hours. The cost of the electrical energy used in the estimate is one cent per 50 watt hours, the prevailing price at the present day.

The potential in these experiments was constant, the same as any ordinary central station endeavors to maintain. The resistance of the filament increases as the lamp continues to burn, and the total energy used, when the potential is constant, decreases and the lamp takes less current to a small extent than when it starts to burn. The relation of the candle power to the total energy shows, though less energy is used as the life continues, that the economy of the lamp is greatly lessened, because the light produced decreases (due to the depreciation of the filament and the discoloration of the glass) in a much greater proportion than the total energy.

As the light decreases in a much greater proportion than the energy, which is what we pay for, the light being the result, however, that we desire, it is easy to see that we are paying more for our light as the lamp continues to burn.

If we wish to maintain a constant candle power throughout the entire life of a lamp, the electromotive force would have to be raised as the filament increased in resistance. The discoloration of the glass and the depreciation in the quality of the filament also make an additional increase in the electromotive force necessary. The current is maintained up to what it was at the start, and even increased. Thus the energy required to produce a constant supply of light would be constantly increasing, and, therefore, the cost of the light constantly increasing as the life of the lamp continued.

Dr. Philip Atkinson, of Chicago, in a recent lecture in which he advocated the economy of the renewals of incandescent lamps at much shorter intervals than the usual practice, unfortunately gave as the reason that the filament's resistance was reduced the longer the lamp was used, whereby the current in increased, while at the same time the luminosity is decreased. He is wrong in regard to the resistance of the filament and the increase of current, for the incandescent lamp as it grows old takes less current whenever the potential is constant. Attention is called to Dr. Atkinson's reasons so that otners may not be misled by his incorrect premises, even though they may have been used to prove an assumption that is supported by facts. There is nothing so detrimental to a cause as false and incorrect premises.

The financial results in table "B" are very clear and plain, and any one would say at a glance, allowing that a 16-c. p. lamp costs 50 cents, that it would not cost the consumer a cent more for light if he bought a new lamp at the end of 900 hours, for the saving in current would pay for the lamp; that much is apparent. However, the following table makes the matter clearer, and more closely defines the line of the most economical life of the lamp. The lamps are assumed in this table to cost the consumer 50 cents; the cost of the current is from the table just previous to this:

TABLE C.

	Cost of current for 16 c.p.	Cost of lamps.	Total cost current and lamps for 1,000 hours.
Lamps replaced every 100 hours.....	$10.80	$5.00	$15.80
" " " 200 "	11.20	2.50	15.70
Figured on a basis of 1,200 hours, and reduced to 10-12 lamps replaced every 300 hours.....	11.66	1.66	13.32
Figured on a basis of 1,200 hours, and reduced to 10-12 lamps replaced every 400 hours.....	12.05	1.25	13.30
Lamps replaced every 500 hours	12.34	1.00	13 34
Figured on a basis of 1,200 hours, and reduced to 10-12 lamps replaced every 600 hours.....	12.68	.83	13.51
Figured on a basis of 1,400 hours, and reduced to 10-14 lamps replaced every 700 hours.....	12.81	.71	13.52
Figured on a basis of 1,600 hours, and reduced to 10-16 lamps replaced every 800 hours.....	13.05	.62	13 67
Figured on a basis of 1,800 hours, and reduced to 10-18 lamps replaced every 900 hours.....	13.30	.55	13.85
Lamps replaced every 1,000 hours.....	13.55	.50	14.05

The result of the above compilation shows for this grade of lamp at the price of current and price of lamp assumed that though the lamp will last 1,000 hours it is better to throw the lamp away at the end of 400 hours and use new ones. Seventy-five cents per lamp will be saved every 1,000 hours by replacing the lamps every 400 hours instead of keeping one lamp in 1,000 hours.

If the lamps were cheaper and the current the same or dearer it would be cheaper to replace the lamp still oftener than 400 hours. If the current was but half of what is assumed in the compilation, that is, if the current cost but one cent for 100 watt hours it would be cheaper to replace the lamps every 700 hours, cheaper by about 17 cents, for every 1,000 hours. It is not a question of the life of a lamp alone that should determine what lamps should be used, but also the efficiency of the lamp, cost of current and price of lamp.

A mathematical equation should be formed taking all these factors into consideration before the matter should be decided by the central station. Reliable data on the majority of the makes of lamps is not obtainable, and it has been necessary to treat the matter from assumption and from analyzing such data as has been published; but even from mere assumption it is without doubt an assured fact, except when the current is extremely cheap, that an efficient, short-lived lamp is preferable to an inefficient, long-lived lamp.

In making this mathematical equation, the end in view is to determine the efficiency at which the sum of the costs of power and lamps is a minimum, and in order to do this the rate of variation of life of a lamp, with its efficiency, should be known. This variation would have to be given by the manufacturer. To give this equation in the shape of a formula, we will assume symbols to represent the various factors:

Let A = the number of watt hours required by a 16 c. p. lamp, $A \div 16$ would represent the efficiency per candle power.

Let B = the life of the lamp at $A \div 16$ efficiency.

Let Y = the cost of a 16 c. p. lamp.

Let X = the cost of a watt hour delivered at the lamp.

The value of A and B must be ascertained from the manufacturer. Y is the price that has to be paid for the lamp. To obtain the cost of a watt hour, or X, delivered at the lamp, the mean current at the station must be determined. The energy in transmitting the mean current would bear the same ratio to the percentage, figured for the maximum load, as the mean current does to the maximum current. This amount of energy must be subtracted from the total energy developed and the remainder will give the amount of energy used in the lamps. The total operating expenses, less the cost of the lamps, divided by the total watt hours delivered at the lamps, will give the cost of one watt hour. The cost of operating a 16 c. p. lamp for an hour would be the cost of a watt hour, multiplied by the number of watts required by the 16 c. p. lamp, or $X \times A$. The proportion of cost for replacing lamps would be the price of the lamps divided by the life, or $Y \div B$.

The most economical point to run the station would be when the sum of the renewals and the cost of the energy is a minimum, or expressed in a formula, when $(Y \div B) + (X \times A) =$ a minimum.

To give an example of this we will assume conditions. Let cost of lamp = 50 cents, efficiency $A \div 16 = 4$ watts, or $A = 64$ watts; let $X = \$.00016$, an average cost of electrical energy (being .8 of a cent for 50 watt hours), and the life of lamp 1,000 hours; substituting these values in the formula we have

$\$.50 \div 1{,}000 + .00016 \times 54 = ?$, or $\$.0005 + \$.01024 = \$.01074$.

Another lamp costs 60 cents; its efficiency is three watts, or $A = 48$ watts. X = the same as in previous case, $.00016, and the life of lamp 300 hours; substituting these values in the formula, we have

$\$60 \div 300 + \$.00016 \times 48 = ?$, or $\$.002 + \$.00768 = \$.00968$.

The result shows that a lamp costing 60 cents, and having a life of only 300 hours, with three watts efficiency, makes the operating expenses of the station less than if the lamp was only 50 cents, and had a life of 1,000 hours, with four watts efficiency. In fact the three-watt lamp is cheaper, even though the four-watt lamp cost but one cent, and had a life of 10,000 hours, for the cost of the energy alone for the four-watt lamp is in excess of the sum of the cost of lamp and energy in the case of the three-watt lamp. The question is governed very much by the cost of the energy.

The incandescent business has grown upon us so rapidly that we have been unable to keep up with the great advance, and the public has been suffered to remain in ignorance on this one of the most important subjects of the present day. In fact, not only has the public been allowed to remain ignorant, but the great majority of central station men have had no opportunity whatever of gathering such data together as would enable them to fully comprehend the important part the incandescent lamp plays in their business. The renewals have always been considered the bugbear of the central station, but the waste of energy has seldom received the slightest notice.

The success or failure of an electric light central station, as a dividend-earning investment, is of the utmost moment to the agents, manufacturers of electric light apparatus and others who desire to promote the business. It is necessary for the success of those desiring to promote the electric light business that the electric light central stations make money. For the electric light central stations to be financially successful, those operating them should be convinced of the importance of using efficient lamps and of renewing them as soon as their efficiency materially depreciates.

The bugbear that exists in the minds of many central station men that it is the cost of renewal of lamps that represents the great expense should be eradicated and the question of waste of energy so demonstrated that they cannot avoid seeing the advisability of efficiency rather than long life in the lamps they are using.

Talking Across the Street.

An amusing illustration, says the London *Electrical Engineer*, of the longest way round being the shortest way home is given in a paragraph that is going the round of the papers, of two telegraph operators who used to together, one of the Submarine, working to France, and the other of the International, working to Holland. The first requested connection to Amsterdam and thence to

Brussels. This was done, and Brussels was requested to switch on to Calais and Calais to London, at the end of which operation the telegraph clerk who held the line asked his "chum" whether he had found his pipe!

A Gould & Watson Pull-Off Bracket.

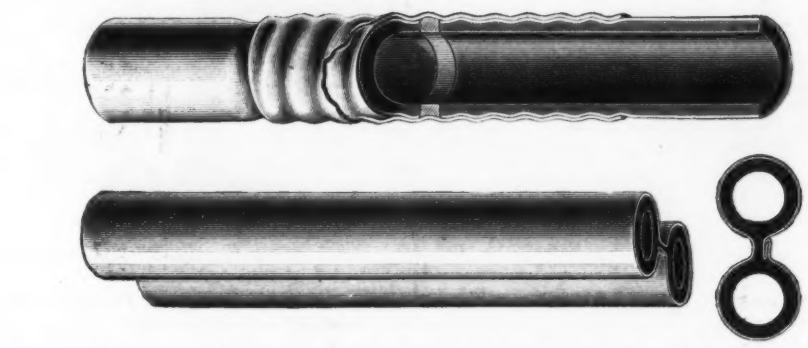
A pull-off bracket, shown in the accompanying illustration, has been placed upon the market by the Gould & Watson Company, of Boston. It is claimed that this piece of electric railway apparatus possesses some advantages in point of strength, combined with high insulating qualities. The insulation is of compressed mica, and the neck of the pull-off is one-half inch steel bent cold. The clip which supports the trolley wire is of composition, and is so constructed that it leaves the under side of the wire unobstructed, thus obviating any undue sparking when the trolley wheel passes across it.

MICA PULL-OFF BRACKET.

Perret Single Reduction Electric Hoist.

We illustrate on this page an electric dock hoist, brought out by the Elektron Manufacturing Company, of Brooklyn. This is a piece of machinery where sirgle reduction is particularly desirable, on account of the saving in space, noise, friction and consumption of current. The motor is a 15 h. p. Perret multipolar, making 450 revolutions per minute, geared by a gun-metal pinion to a 38-inch gear on the drum shaft of the hoist. The drum is one foot in diameter, giving a speed on the hoisting rope of a little over 200 feet per minute.

The motor is shunt wound, and drives the gear wheel at a constant speed, which may be increased, if desired, by the introduction of resistance in the field circuit. By depressing the hand lever the hoisting drum is forced against a friction device revolving with the gear wheel and lifts the load, its speed varying with the pressure on the lever. To lower the load the foot lever is depressed and the hand lever raised. The whole machine is very compact and



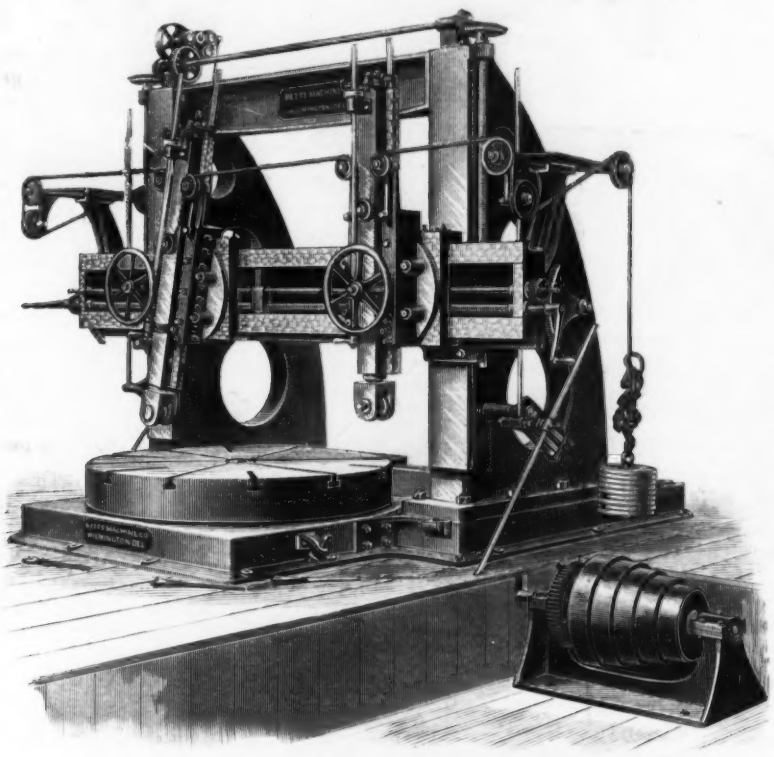
FIGS. 1 AND 2.—METAL COVERED INTERIOR CONDUITS.

Metal-Covered Interior Conduits.

We illustrate on this page a new form of the Interior Conduit and Insulating Company's well known interior conduit. The company has been frequently called upon to furnish a metal-covered tube for decorative purposes, with extra protection against mechanical injury, absolute fireproofing and protection against the deleterious effects of cement.

Fig. 1 illustrates the metal-covered tube. The company's well-known interior tube is drawn through a die, and an outer covering of either brass, steel or iron drawn upon it, fastened and securely sealed by an ingenious lapping of the seam. The tubes are joined together by screw couplings. In order to guard against any liability of moisture or condensation, providing a leak to the outer covering of the tube, a pliable washer is inserted between the two abutting ends of the tube, as shown in illustration, Fig. 1.

Fig. 2 illustrates two separate tubes covered with one piece of metal drawn on as in the case of the one above described. This double tube will be made in sizes one-quarter and five-sixteenths inch inside diameter, and will be found very useful as a substitute for molding. It will doubtless be used largely for exposed work.



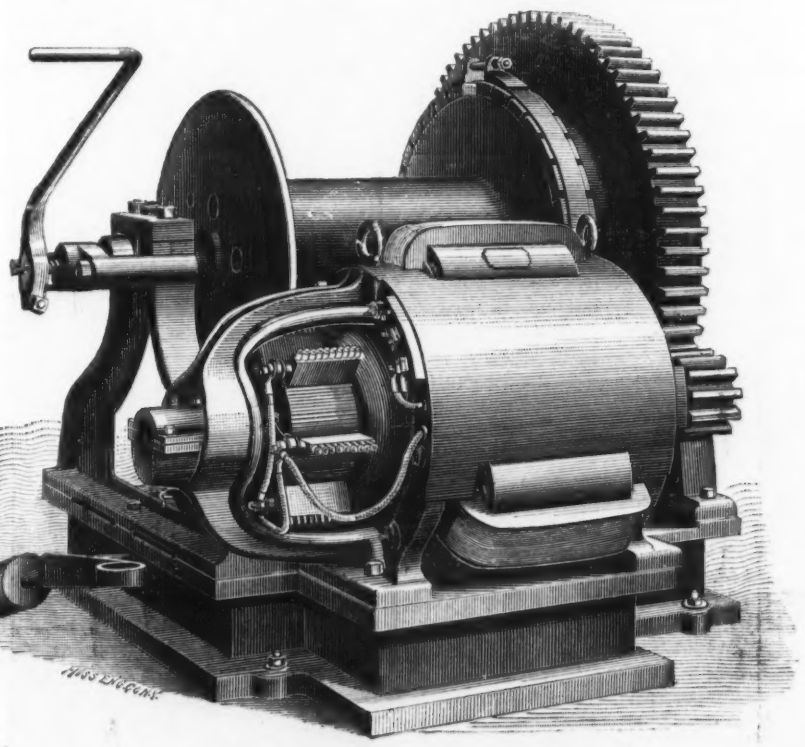
THE BETTS BORING MACHINE.

qualities and strength. The driving shaft is of large diameter, and runs in long bearings. The driving cones are provided with a convenient number of speeds and generous belt width. The uprights are of the box or double plate pattern; have wide faces and long bases. They are amply secured with bolts which fit in T-slots in the side pieces of the bedplate, thus allowing the mill to enlarge its swing. The front ends of the uprights are provided with taper dowels to bring them into alignment again after being moved. Many other valuable features of design, which can be seen from the illustration, make the Betts boring machine one of the best upon the market, and will make it well adapted to the exacting requirements of electrical machine shops.

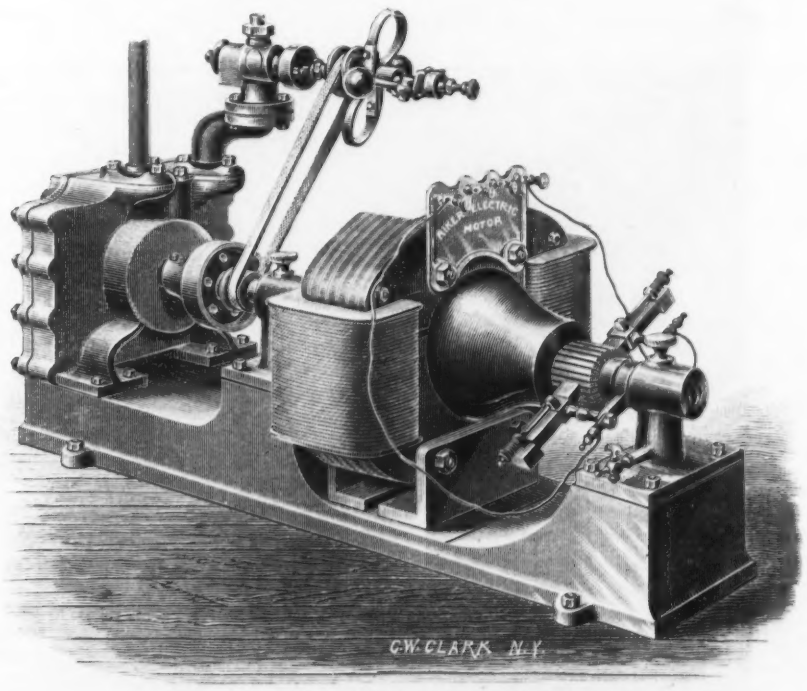
An Improved Boring Machine.

The above cut shows the improved boring and turning mill recently brought out by the Betts Machine Company, of Wilmington, Del. This mill possesses the same valuable features as other mills of this company. The table is driven by an internal spur wheel and a steel pinion, and is attached to a stout and long spindle at its centre. The spindle is carried in an adjustable bearing in the bedplate, while its lower end rests on a steel step and wedge inclosed in another adjustable bearing. On the bottom side of the table is an annular bearing, which is a part of the bedplate, for sustaining heavy loads on the table; when light loads are being handled the wedge under the bottom step can be pushed in by operating a square-ended rod in the bedplate beside the table, thus raising the table off the annular bearing, allowing it to run lightly for faster speeds. The table is well provided with T-slots to secure work, and can also be made with T-slotted arms extending over the edge, thus enlarging the effective diameter of the table.

The driving gears are all cut from the solid, and all pinions are of forged steel. The pitch and face of the gears are large, and have proved very successful in wearing



A SINGLE REDUCTION ELECTRIC HOIST.



A COMBINED ENGINE AND DYNAMO.

Combined Engine and Dynamo.

In the operation of small electric light plants it is often necessary to economize as much as possible in regard to space, and for this purpose some very compact little plants have been designed. One of the neatest of these that has been placed upon the market is shown in the illustration on this page. The dynamo is built to stand upon the same base as the engine to which it is directly coupled. The normal speed is 900 revolutions per minute. In a recent test the dynamo was made to furnish current for 26 incandescent

lamps and one arc. The electrical parts of the plant are supplied by the Riker Electric Company, of this city, and the engine by the L. J. Wing Company, also of this city.

The Nassau Pocket Battery.

This battery is designed by the Nassau Electrical Company, of 112 Centre street, New York, to provide what has long been desired, viz., a battery sufficiently small for pocket use, but at the same time possessing all the strength and other advantages of the large and expensive office batteries. Being operated by the Nassau capsule, which is a dry, close sealed battery, requiring no handling or attention of any kind, it involves no troublesome and dangerous manipulation of sulphate of mercury, bichromate of potash, or other chemicals, or of other wet batteries, but is always ready for use; and in this respect, as in the other details which go to form a perfect battery, it will be found

THE NASSAU POCKET BATTERY.

equally well adapted for the physician and for family use. The induction coil is said to give at least twice the strength of any other coil of the same dimensions.

To start the battery the terminals of the conducting cords are inserted in the holes *A A*, and the lever *C* raised till the vibrator is heard. The strength of the current is regulated by the button *D*, the index on the plate *E* enabling the user to adjust the strength with extreme accuracy from the weakest current to the strongest.

Pressure Regulator.*

BY W. L. PUFFER.

I noticed in THE ELECTRICAL WORLD of Jan. 31, 1891, an illustrated article on "The Holtzer-Cabot Pressure Indicator," and as the subject matter must have been furnished by that company, directly or indirectly, it might be inferred that the instrument is solely of their invention and design. I write to correct this impression, for the simple reason that the company borrowed from me about a year ago one of the regulators then in use in the dynamo room of the Rogers Laboratory of Physics, after asking me if I had any objection to letting them make one to use in a plant in Brookline, Mass.

The accompanying illustration is reproduced from a photograph of a part of the dynamo room, showing two of the regulators in place. The one on the right has been in use since the fall of 1888, and the other for a little over a year. This latter one is the one I loaned as a pattern.

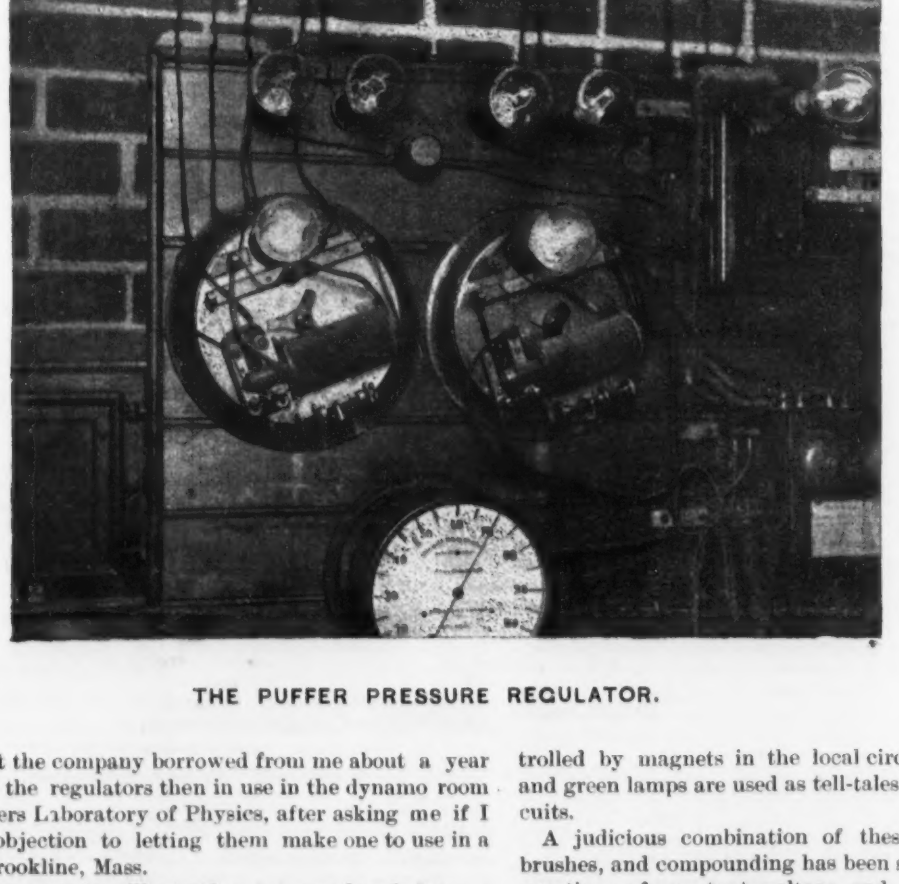
I designed this arrangement in the winter of 1887-8 for use in our laboratory to maintain a constant voltage at the centre of distribution of our wiring system. These regulators hold the voltage within one-quarter volt of the standard 110, under the trying condition of a laboratory dynamo which must run incandescent lights, storage batteries, arcs, motors and the like at the same time with delicate photometric testing of incandescent lamps and the general testing circuits.

I have even run them as close as one-eighth volt either way, but it is almost impossible to do this, as it is much closer than the rest of a plant can be run.

The instrument is a two-point relay with a solenoid slightly inclined from the horizontal, and capable of slight adjustment. The laminated core hangs freely by platinum or steel strips with no friction. The forces are gravity and the current. A charge of one per cent. will move the contact point about half an inch, thus allowing a very close setting if necessary. The mechanical work of moving the resistance box arm is done by oscillating pawls controlled by magnets in the local circuits of the relay; red and green lamps are used as tell-tales in these magnet circuits.

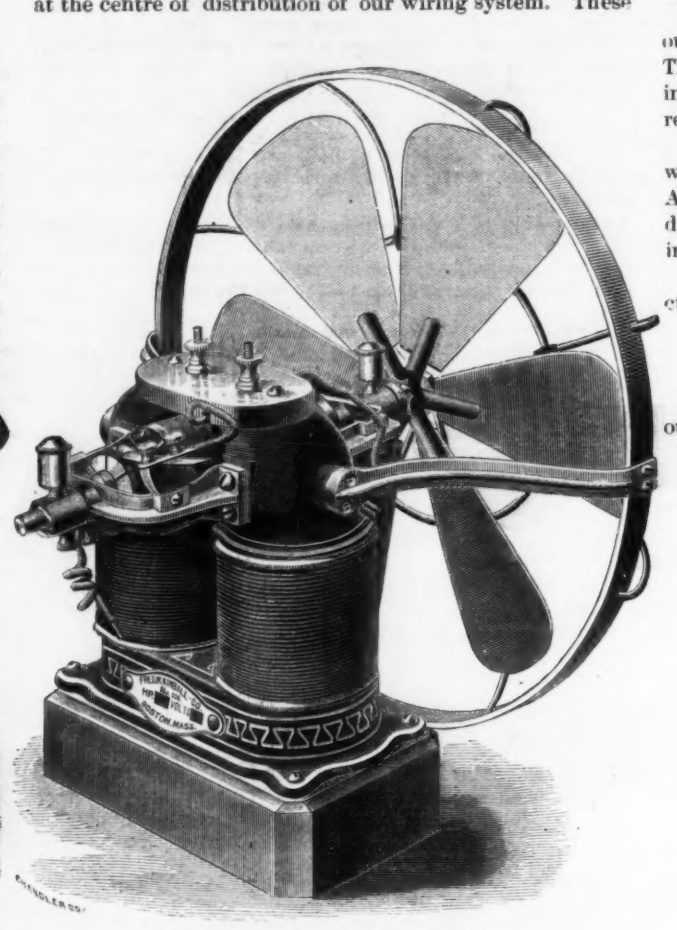
A judicious combination of these regulators, carbon brushes, and compounding has been so successful that the questions of constant voltage and the shifting of the brushes are scarcely thought about. I am sorry to be obliged to write so long a letter, but the facts certainly deserve to be presented in justice to myself, as the originator of the instrument in question.

ROGERS LABORATORY OF PHYSICS, Boston, Mass.



THE PUFFER PRESSURE REGULATOR.

*[It is but fair to the Holtzer-Cabot Company to say that its indicator is claimed to be much modified from that originally constructed.—ED. E. W.]



KIMBALL'S FAN OUTFIT.

Kimball's Electric Fan Outfit.

We show on this page one of the latest of the many fan equipments now on the market, this one being built by Messrs. Fred. M. Kimball & Co., of Boston.

It is very neatly and strongly built, and all of the various parts are made by special tools and to standard sizes. The armature is of a new and special type of winding, the insulation being such that the chances for "burn-outs" are reduced to a minimum.

The commutator bars are made of composition, insulated with mica. The segments are deep and allow of long wear. All of the various pieces are perfectly interchangeable and duplicate parts may be readily fitted in place without sending the entire machine to the factory.

These motors are wound for 50, 75 and 110 volts direct current.

Novelty Electric Fan.

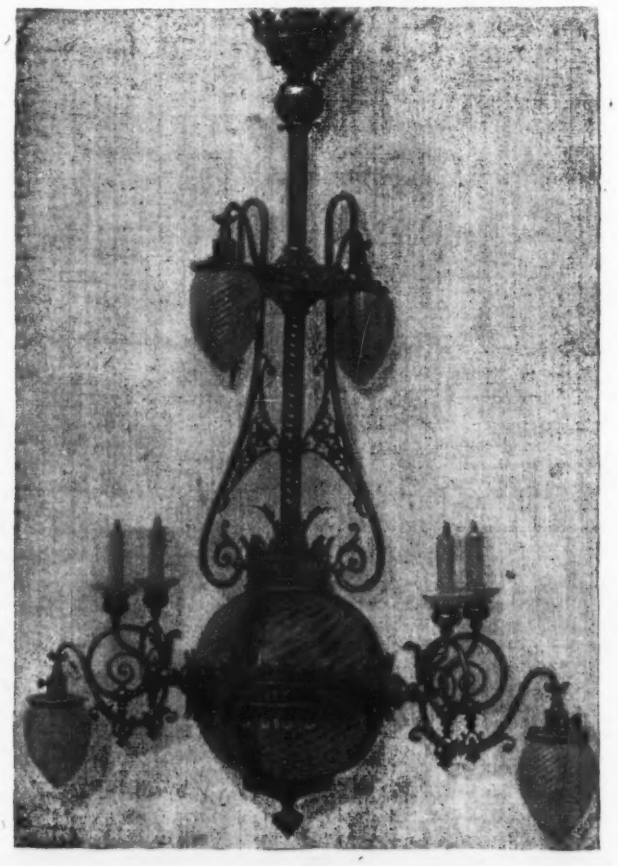
In the accompanying cut is shown a neatly designed fan outfit placed upon the market for the coming season by the Novelty Electric Company, of Philadelphia. As will be seen, it is mounted upon a pedestal, which can be placed in either the position shown in the cut or may be inverted and hung from a ceiling. It is strongly and neatly made and can be operated either from a battery of primary cells or from an incandescent lighting circuit, and, as it is portable, may be moved to any convenient place in an office or dining-room.

NOVELTY ELECTRIC FAN.

A Neat Combination Fixture.

The accompanying illustration shows a decidedly graceful combination fixture manufactured by the W. C. Vosburgh Manufacturing Company, of 418 and 420 Fulton Street, Brooklyn. The total length of the fixture, as shown, is 48 inches, and its spread 34 inches. It is arranged, as will be seen, for 10 lights. This fixture is typical of those manufactured by the Vosburgh company, and is not only substantially made but is handsomely finished and decorated in a very artistic style.

This and many similarly artistic designs are the result of a long experience in the business of supplying fixtures for a great variety of purposes and in almost every conceivable combination.



COMBINED ELECTRIC AND GAS FIXTURE.

Financial Intelligence.

THE ELECTRICAL STOCK MARKET.

This department will be pleased to answer any question in regard to electrical stocks and bonds. Address FINANCIAL EDITOR ELECTRICAL WORLD.

F. Z. Maguire & Co., electrical securities, 18 Wall street, New York, send the following closing quotations of Electric Stocks, on Saturday, April 18, 1891, in New York, Boston, Washington and Pittsburgh:

Name of Stock.	Par.	Capitalization.	Bid.	Ask'd.
NEW YORK.				
Western Union Telegraph Co	100	86,200,000	81¼	81¾
American Telegraph & Cable	100	14,000,000	82	....
Central and South American	100	5,000,000	*145	160
Mexican	100	2,000,000	*210	220
Commercial Cable Co	100	7,716,000	105	106½
Postal Telegraph Cable	100	5,000,000	39	41
Edison General Electric Co	100	9,503,500	96¼	96¾
" " " " deferred	100	2,496,500	....	....
Consolidated Electric Light	100	1,929 400	....	....
Edison Electric Illuminating Co	100	2,567,800	78	....
United States Electric Light	100	1,500,000	30	....
North American Phonograph	100	6,200,000	....	....
BOSTON.				
Thomson-Houston Electric Co	25	6,000,000	47	47
" " preferred	25	4,000,000	25¾	26
" " Series C	10	400,000	9	10
" " Series D	10	120,000	7¼	7½
" International Co	100	1,000,000	....	....
Thomson Welding Co	100	1 000,000	....	....
" European Welding Co	100	1,000,000	55	60
Ft. Wayne Electric Co	25	4,000,000	13¼	13⅜
Telephone:				
American Bell	100	12,500,000	205	205½
Erie	100	4,800,000	48¼	49
New England	100	10,504,600	50½	....
Mexican	10	1.280,000	85c.	....
Tropical American	10	400,000	85c.	90c.
MISCELLANEOUS.				
Edison Phonograph Doll	10	1,000,000	50c.	....
WASHINGTON.				
Pennsylvania Telephone	50	750,000	25	....
Chesapeake & Potomac	100	2.650,000	58	62
American Graphophone	10	600,000	5½	6
United States Electric Light (Washington)	100	300,000	174½	180
Eckington and Soldiers' Home Electric Ry	50	352,000	55	58
Georgetown and Tennallytown	50	200,000	62	64½
PITTSBURGH.				
Westinghouse Electric Mfg. Co	50	5,000,000	14	14¼

*Ex dividend.

Chicago Quotations.—Col. S. G. Lynch, broker, 153 Monroe street, Chicago, furnishes quotations on telephone and electric light stocks as follows:

Chicago	$225@$245	Cumberland	$60@ $62
Central Union	56@ 57	Wisconsin	118@ 120
Michigan	85@ 86	Bell of Missouri	160@ 165
Great Southern	30@ 32	Iowa Union	20@ 22
Colorado	34@ 36	Missouri and Kansas	54@ 56
Rocky Mountain Bell.	40@ 43		

ELECTRIC LIGHT STOCKS.

Chicago Arc Light and Power	$105@$106	Chicago Edison Co	$140@$150

Thomson-Houston.—The annual report of the company is a complete and satisfactory one. It presents a statement of earnings from 1883 to 1890. The growth looks to be gradual, and shows tremendous increase from small beginnings. The earnings for the year of 1883 were $426,987; for 1890 the earnings were $10,617,661.67. These figures relate alone to transactions of the Boston office, and do not include business secured in branch offices. The report states that "such business added to that of the Boston office would increase the operations above 25 per cent." The report then runs at length upon the alliances it has made with other companies. It states that nearly 90 per cent. of the company's business has been in the sale of its apparatus to corporations organized to furnish light and power from central lighting and power stations. "The business of these corporations," says the report, "is profitable and constantly increasing, and the orders received from them for increased plant and for renewal, apparatus and supplies are secured with comparatively little solicitation or expense, and are chiefly for cash." The quotation given in the paragraph before is an indication that local companies are doing good business, increasing plant and paying as they go. This point is of value to the investor, and gives him an opportunity to see from an inside view that local electrical light securities, representing well-managed companies, are worthy of serious consideration as a first-class investment. In further substantiation of the statement made the following paragraph gives specific proof: "The profits received from the different 'series' of trust securities, together with dividend of 40,000 shares of common stock commuted at $25 per share, have have been equivalent to an average annual dividend to the holders of the common stock of a little more than $14 per share during the eight years of the present management of the company. . . . In addition to these dividends, there is an accrued surplus derived from the profits of the company, exclusive of premiums received from the sale of common stock, of $4,522,533.71."

The Stockholders' Meeting held at Middletown, Conn., at which the report was read, was perfectly harmonious and the report not questioned. The President said at the close of the meeting that he understood some of the directors desired to retire, and intimated that perhaps some of the officers might also resign. Article 10 of the by-laws was so changed that five directors instead of four make a quorum.

To be Listed.—It is said that an "application has been made to the Boston Stock Exchange to list regularly the capital of the Detroit Electrical Works, of which James McMillan is president, William A. Jackson, vice-president, and United States Senator Hugh McMillan a director. The company manufactures electrical machinery, car motors, etc., but does not do a lighting business. Its capital has been $500,000, but has lately been increased to $2,000,000, in order to provide for a growing business. Of the new capital only $500,000 will be issued the present season. Par for the stock is $10. The company formerly paid cash dividends, but has put the earnings into plant for a couple of years, and paid dividends in stock. All stock sold has, it is said, been sold at par. The company owns the Rae electric system, which both the Edison and Thomson-Houston companies have, it is understood, endeavored to buy."

The Mexican Telephone Company has submitted plans to the city council of Mexico City for a reconstruction of its wire and pole service. It is proposed to substitute for the existing arrangements iron poles 30 feet long, carrying cables not more than one and a half inches in diameter in certain districts, requiring some five miles of cables. In other districts 30-foot wooden poles may be used to carry not more than 16 wires. The only municipal tax payable by the company for 15 years is 50 cents per pole per month. In addition the company agrees to carry gratis for the municipality a system of electrical fire alarms. Not later than three months after the approval of the contract by the governor of the federal district the company must begin to erect cables, putting up at least 20 iron posts every three months. The new fixtures must all be in place within two years after the approval of the concession. The duration of the contract is to be 12 years from the time when the erection of the new fixtures is completed.

The Erie Telephone Company.—At a regular meeting of the Erie Telephone Company's stockholders, it was voted unanimously to ratify the action of the directors regarding the sale of the Southwestern division. Thirty-one thousand shares were represented.

The American Bell Telephone Company.—The stock of this company has been rising during the week and closed at 205, which is a gain of 6½ points for the week. Edison stock has declined during the week and closed at 96¼, which is a loss of 1¾ points since last Saturday.

Westinghouse is having a good market, and closed stronger than last week. F. Z. M.

NEW INCORPORATIONS.

The Yoakum (Tex.) Electric Light and Ice Company has been incorporated. The capital stock is $50,000.

The Sub-Surface Electric Company, of Jersey City, N. J., with a capital stock of $2,000,000, has been incorporated to deal in electric appliances.

Downer's Grove (Ill.) Electric Light Company has been incorporated to furnish electricity for lighting purposes. The capital stock is $250,000. The incorporators are: E. G. Foote, C. F. Linscott and E. H. Prince.

The Philadelphia Electric Service Company, of Camden, N. J., consisting of F. M. Brinley, E. W. Dwight and Samuel N. Wray, has been incorporated, with a capital stock of $100,000, to carry on business under certain electric patents.

The Quincy (Mass.) Electric Freight Railway, with a capital stock of $300,000, has petitioned the legislature for incorporation. Among the signers are John Quincy Adams, Henry L. Higginson, and Mr. Armstrong, of Kidder, Peabody & Co.

The Bay City Gas, Water and Electric Works has been incorporated at Lodi, Cal. The business of the new corporation is to build, equip, and operate gas, water, and electric works. The capital stock of the company is $100,000, to which the subscribers are: George G. Buckland, J. D. Fisk, S. T. Dodson, James L. Vaughan, all of Lodi, and George Hornage, Stockton.

The Ruby City (Wash.) Water, Light and Power Company has been incorporated. The objects of the company are to equip and maintain an electric light and power plant, electric street railway and telephone exchange in Ruby City. The capital stock is $100,000, divided into 1,000 shares, at $100 each. The trustees of the new company are S. Litchenstadter, John R. Reavis, Allan V. Garratt, W. W. Weeks, George W. Harley.

AFFAIRS OF THE COMPANIES.

The Postal Telegraph and Cable Company is about to absorb the Michigan Postal Telegraph Company. Negotiations have been in progress for some time, and they will probably be consummated at an early date.

The Atlantic and Postal Telegraph Cable Company, a sub-company of the Postal Telegraph and Cable Company, held an annual stockholders' meeting last week. Of the 500 shares of stock 445 were represented. The following directors were re-elected: A. B. Chandler, W. H. Baker, E. C. Platt, J. O. Stevens and T. L. Cuyler. Mr. Chandler was elected president, Mr. Baker vice-president, Mr. Platt treasurer and Mr. Stevens secretary.

The Mexican Telegraph Company held its annual meeting of stockholders last week at the Astor House, New York City. President Robert Colgate presided. The amount of stock represented at the meeting was 104,000 shares. The report of the treasurer, W. French Smith, of Boston, showed that all outstanding obligations have been liquidated. The following officers and directors were elected for the coming year: president, Robert Colgate, New York; secretary, W. H. Harrington, Boston; treasurer, W. French Smith, Boston; directors, Orrando P. Dexter, New York; John D. Sargeant, Robert Bacon, Boston, and James H. Dawes, Kingston, Mass.

Electric Club Elections.—The fifth annual meeting of the Electric Club was held last week at the club-house, No. 17 East Twenty second street. The club is in a flourishing condition, having at present 350 active members. The officers elected were: President, Samuel Insull; vice-presidents, Charles W. Price, Erastus Wiman, W. L. Candee, Edward Weston; secretary, S. L. Cole; treasurer, George M. Phelps; board of managers, H. L. Shippey, P. H. Alexander, T. C. Martin, C. E. Stump, E. F. Peck, E. E. Bartlett, Dr. J. B. De Levy, H. D. Cheever, Charles D. Shain, Joseph Barre, C. O. Baker, Jr.; H. D. Stanley and J. H. Herrick; committee on membership, Charles Dutton, C. H. Barney, George T. Manson, S. S. Wheeler and Joseph Wetzler.

The Union Switch and Signal Company, of Pittsburgh, Pa., has issued a statement of its condition through its new president, Mr. G. H. Goodman. A comparison between the business of 1889 and that of 1890 shows a difference of 34 per cent. in favor of the latter year. For the year 1890, the earnings from sales were $760,869.08. The expenses were as follows: Operating expenses, $647,708.24; settlement of old accounts, $20,839.95; a total of $668,548.19. The net earnings, therefore, over and above operating and other expenses, were $92,320.89. The interest on bonds, $17,766, and also the interest and discount, which amounts to $1,250.96, being deducted, leaves a total of $28,016.96, with net earnings over expenses and interest of all kinds of $64,303.93. The report of the company's finances is as follows: Assets available - Cash on hand, $24,134.99; bills and accounts receivable, $444,278.50; material on hand at cost, $119,893.54; total available assets, $588,307.03. Assets unavailable—Real estate, $149,080.22; machinery and fixtures, $42,045.04; hand tools, $16,911.69; office furniture, $2,332.74; sundry stocks, $12,328; patents at capitalized valuation, $1,038,240.36. Total unavailable assets, $1,310,938.05; making the assets of all kinds aggregate, $1,899,245.08. Liabilities—Preferred stock, $370,100; common stock, $964,650; capital stock, $33,300; first mortgage bonds, $296,100; bills payable, $378,854.28; accounts payable, $94,243.98; interest on mortgage bonds, accrued but not due, $5,562; mortgage on Swissvale property, $15,000; total liabilities of all kinds, $2,157,810.26; balance to debit of profit and loss, $258,565.18. The contracts made during 1890 were as follows: For interlocking switches and signals, $458,173.50; electrical signals, bells, etc., $143,694.23; frogs and switches, $82,404.70; sundries, $61,821.47; total, $746,094.30.

Special Correspondence.

NEW YORK NOTES.

OFFICE OF THE ELECTRICAL WORLD,
167-177 TIMES BUILDING, NEW YORK, April 20, 1891.

Mr. B. Whitehorne, formerly with the Accumulator Company, is now representing Messrs. Truex & Vail throughout New York State and vicinity, and is doing a good business.

The Standard Paint Company, of New York, manufacturers of P. and B. paint and insulating compounds, will remove from the present offices on May 1 to No. 2 Liberty street, corner of Maiden Lane.

Mr. Eugene M. Smith, electrical engineer and contractor, for several years with the Ball Electric Company, is now settled in his new office at 14 Dey street, New York City. Mr. Smith has been quite busy lately with installation work in the South.

Mr. Louis Walsh, formerly with the Crosby Electric Company and one of the most expert battery salesmen in the country has resigned, and will take charge of the new battery department about to be opened by Messrs. Alexander, Barney & Chapin. The A. B. C. Company is to be congratulated on securing the services of Mr. Welsh, as his knowledge of batteries is complete. He has always been a unique advertiser for whomsoever he has represented, and no doubt will soon make the A. B. C. company more popular than ever.

An Electric Light Company Retaliates.—A portion of the city was in darkness last week, because the Brush Electric Light Company, desiring to be on the safe side and not wishing to come in contact with Mayor Grant and the Board of Electrical Control, quietly went to work, and, with an ample force of men, stripped from its poles all the electric light wires and, coiling them up, carted them away in wagons. Then with axes the gang of men cut the poles, throwing them into the street, thus effectually and completely shutting off that part of the city from the use of the electric light until the subways are properly established in that part of the city.

Mr. A. H. Bauer, electrician of the Pullman Palace Car Company, was in New York last week. The department over which Mr. Bauer presides now employs nearly a score of electricians and an addition is soon to be made to the force. The President's train, in which General Harrison is now traveling in the West, is elaborately fitted up so far as electricity is concerned. There are two C. & C. motor fans in the observation car, two in the smoking car, and two in the dining car. There are 144 16-c. p. lamps in the five cars. The Brotherhood engine and the Eickemeyer dynamo are in the baggage car, and steam is taken direct from the locomotive. Mr. Geo. H. Betts is the electrician who has charge of the electrical features of the train. L. H. H.

NEW ENGLAND NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
Room 28, Hathaway Building, 620 Atlantic Ave.,
BOSTON, April 18, 1891.

Mr. H. M. Nichols, New England agent for the Star Electrix Company, has been receiving some very large orders during the past week for the popular "Star" specialties.

Mr. Jerome W. Doten, son of F. B. Doten, of the First National Bank of Chicopee, Mass., has connected himself with the Standard Electric Supply Company, of Boston. Mr. Doten will travel for the above company.

Messrs. J. A. Grant & Co. are at work on the installation in Baltimore, Md., of an 800 h. p. steam plant complete, consisting of McIntosh & Seymour engines and Babcock & Wilcox boilers, to use steam at 140 lbs. pressure.

The New England Telephone Employes' Ball was held at Odd Fellows' Hall, at Boston, last week. It proved to be an unqualified success in every respect. Certain it is that "Central" never looked more charming nor as free from care as she did upon this occasion.

Bridgeport, Conn.—The Wardell-Entz Electrical Company, of New York, has leased the old Hotchkiss factory at the West end, and will move its works there from Brooklyn in May. The concern has a capital of $1,000,000, manufactures electric light plants, etc., and will employ 250 men.

Messrs. J. E. Wilson & Co., the agents for the Rollins engine of Nashua, N. H., have secured during the past week the contract from the Concord (N. H.) Electric Street Railway Company for a 250 h. p. engine, including shafting, pulleys, etc. This engine is to be especially heavily built for the severe duty of electric railway work.

The Massachusetts Electrical Engineering Company is fitting up a new laboratory and testing-room on Fort Hill square, Boston, which will be, without exception, one of the most complete establishments of the kind in the country. The fast increasing business of this company is practical evidence of the growing popularity of this branch of the electrical service.

Consolidated Electric Manufacturing Company, of Boston, reorganized under the management of Mr. C. E. Bibber, is booming. New workmen have been added in every department, and many orders have been received for various supplies. The new "C. E. M." socket just brought out by this company has been received with marked favor, one order alone of 10,000 having been received from Chicago last week.

Mr. Sprague, of the mining department of the Thomson-Houston Electric Company, gave a very instructive lecture on electricity, as applied to modern mining, illustrating the same on blackboard and by stereopticon views. Mr. Sprague has a very pleasant way of holding the attention of his audience by making it more of an informal talk than the stereotyped lecture, and it is safe to say his remarks lost none of their worth by so doing.

Municipal Lighting.—The committee on manufactures of the Massachusetts Legislature has reported unanimously a bill to enable the town of Danvers to erect and maintain an electric lighting plant; also similar separate bills for Hingham, Melrose, Peabody and Marblehead. On the petition of the Boston Common Council for a law to enable Boston to enjoy the same privilege, the committee unanimously reported "leave to withdraw."

Lynn, Mass.—An interesting paper was read before The Thomson Scientific Club on Thursday, April 16, by Mr. H. S. Rodgers, on "The Development of the Electrical Street Railway Systems at Cincinnati, Ohio." He dwelt on the pecular difficulties of construction encountered there, on account of the double trolley system, operated by independent companies, in some streets there being several different lines of double trolley roads, besides a cable line.

The Cambridge Accumulator Company has had a rather severe test made of one element of its new storage batteries by the Massachusetts Electrical Engineering Company, for traction work. The cell was set to discharging at 100 ampères, the current being kept as nearly constant as possible, and the potential was main-

ained under this discharge for 45 minutes. The cell then showed wo volts on open circuit. It was then set to discharging at 50 ampères, which it maintained for 30 minutes, afterwards the cell till showed two volts on open circuit. It was then set to discharging at 15 ampères, which it maintained for two hours. The total discharge under this forced output was 134 ampère-hours. The cell showed no deterioration.

Prof. Elihu Thomson delivered an address in Lynn, Mass., ast week in Odd Fellows' Hall upon the subject of "Light." The ecture was under the auspices of the Electric Mutual Benefit Association. In addition to the lecture there was an orchestral concert. A souvenir of the occasion was a picturesque pamphlet containing an illustration of the first Thomson-Houston factory at New Britain, Conn., also engravings of the present quarters of the company in West Lynn. A feature of the pamphlet was a carefully prepared article by Prof. Thomson, also a history of the Thomson-Houston Electric Company, Thomson Electric Welding Company, Electric Mutual Benefit Association, Electric Co-operative Supply Company and Thomson Scientific Club. C. A. B.

PHILADELPHIA NOTES.

Branch Office of The Electrical World,
13 City Trust Building, Philadelphia, April 18, 1891.

Mr. H. B. Cutter is installing an Echo magneto clock system at the Penn Mutual Building, Chestnut street, Philadelphia.

The Spellier Electric Time Company has installed at the Bryn Mawr School, Baltimore, Md., a system of electric clocks. By this means the different school rooms are supplied by accurate time; as these clocks are energized entirely by electricity it obviates the necessity and trouble of winding.

The Thomson-Houston Electric Light Company reports the following installations from the Philadelphia office last week: A 1,350-incandescent light plant for the Williamson School, Elwyn, Pa.; a 100 arc light plant for the Home Electric Light Company, Tyrone, Pa.; a 45 arc light plant for Messrs. Alan Wood & Co., of Conshohocken, Pa., and a 650 incandescent light plant at Madison, N. J. W. F. H.

Uniontown, Pa., April 18, 1891.

Uniontown, Pa.—The electric light and illuminating gas plants of this place are now under one and the same management, that of the United Light Company, this company having purchased the stock of the Uniontown Electric Light and Power Company, and of the Uniontown Light and Heat Company. The United Light Company was chartered in December last with a capital stock of $100,000. Hon. J. K. Ewing is president, and W. G. Hay, secretary, treasurer and general manager. The board of directors are: S. E. Ewing, E. S. Hackney, A. D. Conwell, Arthur Strickler and J. K. Ewing, Jr., of this place, and A. Q. Keasby, of Newark. Under its charter the company has the right to operate works for the manufacture and supply of light, heat and power by gas, natural gas, electricity and otherwise; to manufacture electrical machinery and appliances. The Electric Street Railway Company will have all their cars running by May 1st. The power house is completed, motors fitted to the cars, track and trolley line completed, and workmen are busily engaged setting up the dynamo, engine and boiler. The same company intends commencing work at once on the New Haven line, 12 miles north of here, which will connect New Haven and Connellsville directly with the works of the largest coke operators in this State, where several thousand men are employed. The road is to be three miles in length. The Edison-Sprague system will be used. The owners of the Grindstone coal mines, near Brownsville, Pa., 19 miles south of Uniontown, are having an electric hoisting and haulage system placed in their mine. A number of the most prominent coal and coke operators say they will probably have their mines lighted by electricity this season. Some of them will employ motors for hauling the coal to the foot of the shafts when practical. J. O. F.

WESTERN NOTES.

Branch Office of The Electrical World,
465 The Rookery, Chicago, April 18, 1891.

Mr. Fred DeLand has again assumed the management of the Western office of The Electrical World, 465 The Rookery, vice Mr. Eddy, who has resigned.

Mr. Charles Jaeger, formerly of 200 Kinzie street, Chicago, Ill., has removed to 48 Sands street, Brooklyn, N. Y.

Mr. D. E. Goe, formerly of Memphis, Tenn., is now in charge of the advertising department of The Electrical Supply Company of Chicago.

The Electrical Construction Company, 175 Randolph street, Chicago, is wiring the mammoth Leiter building on State street for 1,200 lights, and is using Habirshaw insulation throughout.

Mr. J. W. Godfrey, the well-known manager of the New York Insulated Wire Company, 651 Broadway, New York, is a welcome visitor in Chicago, where he is talking up the merits of the new form of interior conduit he is placing on the market.

Mr. C. F. Reynolds, of San Francisco, Cal., the well-known railway authority of the Pacific Slope, who was in Chicago on Thursday en route home from the East, spoke highly of the excellent showing made by the new Westinghouse noiseless railway motor, and of the courtesies extended by Mr. H. McL. Harding during a recent visit of Mr. Reynolds and his party to Pittsburgh, where every portion of the great works of the Westinghouse company was thrown open to their inspection.

The Chicago Electric Club held its annual election on Thursday evening, and elected the following officers for the ensuing year: President, B. E. Sunny; vice-presidents, F. B. Badt, Alexander Kempt, D. P. Perry, George C. Bailey; secretary, W. A. Kreidler; treasurer, F. S. Terry; managers, F. E. Degenhardt, E. Baggot, J. P. Barrett, F. G. Beach, W. H. McKinlock, E. R. Gilman, M. A. Knapp, F. W. Parker, W. B. Pearson, C. H. Wilmerding; membership committee, C. C. Haskins, George Cutter, G. A. E. Kohler. As there were several tickets in the field, the contest was a fairly warm one, 75 members casting their votes, but the best of feeling prevailed, and the successful candidates were warmly congratulated by all. Mr. Sunny in accepting the presidency spoke of the excellent showing, especially in the growth of membership, made by the retiring president, Mr. Franklin G. Beach, and, feeling that the members appreciated the excellent influence the club could exert in furthering the commercial and scientific interests of electricity, trusted that all would aid him in continuing the good work of his predecessors. Mr. Sunny is one of the charter members of the club, has always been one of its foremost workers, and there is little doubt that he will wield in one active, harmonious body the large membership over which he has been called to preside. The club was honored with the genial presence of its first president, Mr. A. K. Stiles, who has always labored for the best interests of the club, in the formation of which he took such an active interest.

The Columbian Exposition.—The election of Mr. William T. Baker to the presidency of the Columbian Exposition is a matter of congratulation to all, and especially to the large number who are intimately acquainted with his thorough knowledge of business affairs, his high integrity and his conservative methods. That he is now serving his second term as President of the Chicago Board of Trade indicates the high estimation placed upon his ability as a dignified and practical executive officer. Politics do not enter into the question; the object that all the leaders are faithfully bending every energy to accomplish is to make this exposition surpass any that has ever been held, and to be of practical value to the commercial, the scientific and the artistic world. On Friday Mr. Baker announced the standing committees for the new year. The committee on machinery and electrical appliances is as follows: Robert C. Clowry, chairman; Bernard E. Sunny, Charles E. Wacker, Robert Nelson, C. K. G. Billings. It is gratifying to have Colonel Clowry continued as chairman of the committee on machinery and electrical appliances, as he has been active and untiring in watching over and promoting electrical interests, and now, with Mr. B. E. Sunny as his able lieutenant, no department will make faster progress or a department chief have warmer support. General progress of a marked character is slowly but surely being made, about 1,000 laborers being employed on the grounds, and soon tangible results will be evident to all. Director-General Davis returned on Wednesday from Florida, where he has been for the last month recuperating from his recent illness, and was warmly welcomed home. The daily papers contain an illustration of "the electricity building," but no official knowledge regarding it is to be obtained. The published description is as follows: "The building will be 350 × 700 feet. This is the ground floor surface. In addition there will be a gallery at least 24 feet wide running around the entire structure. Provision is also made for an annex as wide as may be necessary along the west side of the structure. The drawing represents an east elevation facing the central canal, but the impressive portion of the building will be the grand entrance at the south end. There are entrances on the four sides of the structure, but the main one will be that on the south. Like all the entrances in general it will be high and wide and in the form of a semicircle. It will be finished with such architectural details as to impress the visitor with its beauty and dignity. After the entrances the notable features will be the four towers, one at each corner. These are designed to be 160 feet high, or 100 feet above the general height of the structure. The towers, it is proposed, shall be brilliant at night with electric lamps. The electrical building in fact will be the seat of light and the towers are to be blazing turrets superior in brilliancy to the display within. In front of the south entrance and facing the Administration Building will be a suitable statue of Benjamin Franklin. The statue will not be of bronze or stone, but of the composition material which is to play such a large part in all the structures." The determined manner in which Chief Barrett is working for a united electrical exhibit and to prevent electrical apparatus from being scattered through other than the electrical building is winning him many warm friends and proves that he is watchful and earnest in guarding the interests of the electrical fraternity. F. de L.

ENGLISH NOTES.

London, April 8, 1891.

Reduction of Telephone Charges.—Following in the wake of the National Telephone Company, the Post Office announces reductions in its charges to the subscribers to the few exchanges which it owns in this country.

A Long Telegraph Line.—Last month one of the longest, if not the longest, aerial telegraph line in the world was opened for public messages. It was between Calcutta and Bombay, across India, and its length is 1,300 miles.

Coast Telegraphic Communication.—The many wrecks which occurred during the bad weather of a fortnight or three weeks ago, combined with the fact that in several instances lives might have been saved had there been telegraphic communication between isolated lighthouses on the mainland and between the signal stations around our coast, has resulted in the revival of the agitation for filling this decided want.

The Telegraph Revenue.—Although the receipts from the postal telegraph revenue for the year 1890-91 show an increase over those of the preceding financial year, the increase is by no means so great as that shown in the year 1889-90. The receipts for the year ending March 31, 1890, amounted to £2,320,000, or £240,000 more than the previous total. The receipts for the year ending March 31, 1891, are £2,380,000, an increase of only £60,000.

An Ingenious Electro-Medical Contrivance.—M. d'Arsonval, the eminent French electro-physiologist, has just brought out an ingenious method of registering simultaneously the potential, the current, the rate of change of potential and "shock" effect for the purposes of medical electricity. If it proves as successful in practice as it is ingenious in theory, this method will enable doctors to separate out the effects of alterations in the various factors which give the electric current its "shocking" properties.

The London-Paris Telephone Wire.—This line was opened to the public to-day, after having been yesterday placed gratuitously at the disposal of the press of the two cities. On Thursday evening last there was a further demonstration of the capabilities of the line by the transmission of music from the Paris opera, the demonstration being of a highly successful character. The line, although in every way satisfactory, possesses one defect, which is perhaps on inevitable one—its balance is easily upset. I am assured that the alteration of a 1-10 microfarad in its capacity means a perceptible difference to the transmission, while the interposition of the coil of an annunciator completely blocks the line.

Glasgow.—The corporation of this large city, which recently issued "fishing" invitations for electric lighting tenders, has only received four replies, emanating from three well-known English firms and the Thomson-Houston Company, of Lynn Mass. As the corporation of Glasgow owns its gas works, progress in electric lighting is of the usual dilatory character; and although the matter has been under consideration these two years, the special committee of the corporation have only got to the "touring" stage, and proposes shortly to visit Bradford and Leeds *to collect information on the subject of electric lighting.* A visit to the States would certainly be more instructive and probably more attractive.

A New Method of Charging for Electricity.—The Paris municipal council has evidently taken to heart a remark which Prof. Ayrton let drop some two years ago at the Society of Arts, on the occasion of the reading of a paper by Prof. Forbes on "Electric Meters." The learned professor pointed out that, although the watt-hour meter was a decided improvement on a mere ampère hour meter, still it was not enough; since although the watts might be all right, the volts might be all wrong and the light consequently of a very indifferent character. Prof. Ayrton then went on to say that the ideal method would be to charge by the illumination obtained. Now, the Paris municipal authorities have endeavored to do something of the kind. They assumed that a light of 10 candles (1 carcel) could be obtained from a burner consuming 3 cubic feet of gas per hour and worked out the cost of a carcel-hour at about 3d. They then decided to allow the electric light companies to charge about 50 per cent. more than the gas company, the price per carcel-hour when produced by electricity being fixed at a little under a ½d. (.432d.). The electric supply companies thereupon said that the ordinary incandescent lamp had a 3-watt efficiency and worked out the charge of a 1,000 watt-hours at 14.4d.; although if we take the more ordinary efficiency of 4 watts per candle the price comes out at 10.8d. Having been given such a magnificent opportunity the electric light companies might say, as did Lord Clive, when accused of peculation, on his return from India, "I am surprised at my own moderation."

Answers to Correspondents.

Questions to be answered in this column must be of general electrical interest, and must be accompanied by real name and address as a guarantee of good faith. No notice will be taken of questions regarding apparatus unless enough details are given to permit a definite answer, and no dynamo or motor designing will be done.

Personality of Earthed Currents.—Will you kindly answer the following questions? (1) When a dynamo is running with a ground return, will a measuring instrument show, when applied to the wire running from the earth to the dynamo, as much current as if it were attached to the wire leading *from* the dynamo to the line, less the amount used in the resistance of the circuit? (2) Would the return current be just the same, say three feet from the dynamo leading *to* it, whether the return be metallic or earth, allowing for their respective resistances? (3) Can the earth return be located, identified and measured the same as in a metallic return, or is the current simply diffused when it reaches the earth and then absorbed again at the other end? In other words, does the current lose its *personality* when it enters the earth, and merely add to the reservoir (the earth), from which is absorbed a similar amount at the negative end? (4) What does hysteresis mean? W. H. S.

(1 and 2) One of the first laws of electrical science to be learned is that the current has exactly the same value at all points of a circuit, barring leakage, and whether you place your ammeter in series with the line near the positive pole of the dynamo, out on the circuit or near the negative pole, the same ampère indications will be given. You must not speak of "current being used up by resistance." A dynamo does not generate a given amount of *current*, but a certain *pressure* (voltage or E. M. F.), and this pressure causes a current to flow in the circuit, and the amount of current depends upon the values of pressure and resistance. (3) As a general thing we can consider that the current is diffused in an "earth." For instance, in the high conducting body of the sea, we cannot imagine that the return current of the Atlantic cable circuit is flowing in a well-defined and slender path; but, between "grounds," a distinct line of conductance might exist, and here we may say the current is not diffused to any great extent. The current will return by the path of least resistance. (4) Hysteresis is defined by Prof. Houston as "molecular friction to magnetic change of stress." The word is used mainly with reference to the losses by internal work other than heating, in the cores of electromagnets of all kinds.

News of the Week.

THE TELEPHONE.

Fargo, N. D.—The entire telephone system will be rebuilt and otherwise improved during the spring.

New York and Chicago Telephone Line.—The long distance telephone line between New York and Chicago is completed to New Castle, Pa., and will be built south to Pittsburgh, Pa., as soon as the weather improves. Mr. Henry Metzgar, general manager of the Pittsburgh telephone system, stated last week that although the recent bad weather gave the work a set-back, the time lost will be made up, and that it will not be long until the cities of New York, Pittsburgh and Chicago are in telephonic communication.

THE ELECTRIC LIGHT.

Venice, Ill.—The city council has passed the electric light ordinance. Mr. S. A. Nieman has obtained the franchise and will furnish the city with 12 arc lights for $1,500 a year.

Chehalis, Wash.—The Council has decided to put in an electric light plant at the cost of $10,400. The committee has ordered the Thomson-Houston arc light and the Edison incandescent light systems.

Bay St. Louis, Miss.—Mr. A. Lesseps, secretary of the Gulf Coast Ice Manufacturing Company, is constructing an electric light plant in connection with the ice plant, for furnishing commercial lights.

The Home Electric Company, of Seattle, Wash., has received another 150-h. p. engine, and is putting it in the new power-house. The dynamos will be moved from the old station of the company next week.

Pittsburgh, Pa.—The Allegheny County Light Company will begin next week to tear down the old foundry building on the property of A. Bradley & Sons, Allegheny, preparatory to erecting the new electric light plant.

Waterford, N. Y.—Mr. George W. Hunt, president of the Hunt Engineering Company, of Brooklyn, N. Y., has secured the Waterford electric light franchise, and will at once erect a plant of 1,000 incandescent and 35 arc lights.

Greenville, S. C.—The gas and electric light plants, which are now run under one management, are to be greatly enlarged. A better location is to be chosen for the electric light plant, and the work of construction will be commenced at an early date.

Norwalk, Conn.—The Norwalk and South Norwalk Electric Light Company's plant on Wilton avenue was burned last week, and many of the streets are in darkness. The superintendent at the works was removed a few days ago, and his friends claim that his removal was unjust and was the work of enemies. It is now thought that the electric light company has enemies and that the building was set on fire. Out of every 24 hours there are only two when the works have no occupants.

THE ELECTRIC RAILWAY.

Pasadena, Cal.—The railroad to the top of Mount Wilson will probably be operated by electricity. It will extend from Altadena up Rubio cañon, and up the west side of Eaton cañon, terminating at a point near the present observatory. It will be 12 miles long, and will have a grade of about seven per cent. The electric plant

will be located in Pasadena, and will furnish power for other purposes. Six cars will be operated.

MISCELLANEOUS APPLICATIONS OF POWER.

London Plant for Charging Boat Accumulators.—Messrs. Woodhouse & Rawson, of London, have arranged for the erection of a permanent charging station on the banks of the river, at Chertsey, under the management of Mr. J. Taylor. The station is now in course of erection, and will be ready to undertake the charging of all sizes of electric launches by the beginning of the river season.

LEGAL NOTE.

Postal Telegraph Company's Railway Lines.—The plaintiff, the Postal Telegraph and Cable Company, wishes to establish a telegraph line on the roadbed of the Norfolk & Western Railroad Company, in the county of Prince George, Va., and some weeks ago commissioners were appointed by Judge Rives, of the County Court, to assess damages. The commissioners were engaged for some days in hearing testimony, and the argument of counsel was concluded last week. The commissioners afterward made their report to Judge Rives. They assess the damages to the railroad company at $200, and decide that the telegraph company shall have the right to erect its poles and run its wires on the north side of the railroad company's tracks. Exceptions have been taken by counsel for the railroad company, and it is thought that the case will probably reach the Supreme Court of the United States. It has already been in the Supreme Court of Appeals of Virginia, from which court it was remanded to the County Court of Prince George.

PERSONALS.

Mr. John Dorrington, chief electrician of Allegheny County Court House, at Pittsburgh, Pa., has been re-elected to the same position by the new board of commissioners.

Mr. Louis W. Burnham, vice-president and manager of the Electric Gas Lighting Company of Boston, Mass., has been in San Francisco, Cal., on business during the past week.

Dr. Mayer, professor of physics at the Stevens Institute, will, with Mrs. Mayer, make an extended tour abroad during the coming vacation, leaving Hoboken during the latter part of June, probably on the 18th or 20th. Dr. Mayer has not been well of late, and it is partly for that reason that he goes, but his trip will not be valueless for that institution.

MISCELLANEOUS NOTES.

The Sims-Edison Electric Torpedo Boat in Europe.—The first European exhibition of the Sims-Edison electric torpedo boat was held at Havre, France, last week, and was a success. A further exhibition, before representatives of the French, English, Russian, Italian and Spanish governments will be held within a few days.

Pennsylvania State Electric Light Association.—As noted some time ago, the electric lighting companies of Western Pennsylvania have formed an association the object of which is mutual benefit. A meeting was held in Pittsburgh last week for the purpose of organization, at which representatives from the towns of Scottdale, Wilkinsburg, Rochester, Beaver Falls, Sewickley and Tarentum appeared. Mr. G. M. Getze, of the Tarentum Electric Light Company, was elected chairman. The members of the association are expected to meet occasionally to discuss improvements and whatever will help the business. A short discussion with regard to the comparative merits of the meter and contract systems took place at the meeting of a few days ago, from which it appeared that the majority of the participants were in favor of the contract basis of charging for the light. Edison, Thomson-Houston and Westinghouse central station companies are represented in the association.

Industrial and Trade Notes.

The Armington & Sims Engine Company has issued a handsome engraved card, announcing a further reduction in the prices of the company's apparatus, and calling attention to its various sizes of engines.

Messrs. Darling, Brown & Sharpe, the well-known wire and tool makers, of Providence, R. I., has received from, Paris, France, a beautifully engraved diploma announcing the award of a gold medal by the Universal Exposition of 1889 for the excellence of the Brown & Sharpe grades.

The L. J. Wing Company, of New York, Boston, Chicago and Cincinnati, manufacturers of the well-known Wing disc fans, has been doing a very rushing business lately as the warm weather comes on. This company has also made a number of sales of motors, dynamos and gas engines recently.

The Bradner Adjustable Lamp Hanger, one of the specialties of the Electrical Supply Company, of Chicago, Ill., possesses both utility and beauty. It enables the user to have his lamp at any desired height without any dangling cord, everything being self-contained in an ornamental brass ball.

The Stanley Electric Manufacturing Company, of Pittsfield, Mass., has issued a very handsome pamphlet, which is devoted to description and test data of the Stanley transformer. The comparative tests of the above transformer, with other converters upon the market, show the Stanley make to be of high efficiency.

The Easton Electric Company has lately issued an addition to its catalogue, calling special attention to the Easton arc lamp, Easton switchboard, current indicator, line cut-outs, and the Claus-Easton continental dynamo. The Easton arc lamp is perfectly adapted for use on incandescent circuits, either singly or in pairs.

The Magnolia Anti-Friction Metal Company has received in the last few days, from London, a copy of a diploma for gold medal awarded to them by the International Electrical Exhibition, held in Edinburgh, Scotland, in the autumn of 1890. This medal was awarded for a special anti-friction metal for bearings of dynamos and other high speed machinery.

The Eddy Electric Company, represented in New York City by Walter C. McIntire, has leased an elegant office suite on the second floor of the New Electrical Exchange Building, 134, 136 and 138 Liberty street, and will remove there May 1. The offices will be beautifully fitted up, and a number of samples of the motors made by this company will be on exhibition.

The Babcock and Wilcox Company, of New York City, has annually, for several years past, issued a most handsome book called "Steam," and though the first edition in 1883 contained an exhaustive treatise upon the use of steam-power, still each succeeding year showed a more complete collection of data and formulæ, together with additional showings well deserved for the Babcock and Wilcox boiler.

Mr. Henry Schwindt, successor of The Smith and Shaw Electric Company, of 610 Eighth avenue, New York City, manufacturers of the well-known "Alpha" Faradic medical coil and the "Triplex" closed cell pocket coil-box, has been doing a very large business in the above specialties during the past year. Mr. Schwindt has a most complete stock and the designs and workmanship of his apparatus make it at once efficient and handsome.

Mr. John Henry Blake, engineer, at 114 Liberty street, New York, has invented and is now offering to the trade a new damper pump and pressure regulator, which is very simple, as all parts are easy of access and can be set up by any engineer or pipefitter. This regulator saves wear and tear of boilers by preventing fluctuations in pressure and supplying steam of even pressure to the engine, which is very important in electric lighting. Mr. Baker is in receipt of some strong letters recommending his inventions from those now using his apparatus.

Messrs. Truex & Vail, of 44 Broadway, New York city, have sold a storage battery installation to E. G. Bernard & Co., electrical engineers, of Troy, N. Y., for the residence of Mrs. Hubbard Hart. They have also sold 20 '15 m" accumulator cells for the use of the Pennsylvania State College, and the firm is also fitting up the private car "Oriental," belonging to Austin Corbin, president of several railroads. This car is very handsome, and the 30 lights, with fixtures of oxidized antique silver, will give additional luxury to its appointments. The lighting of the private cars has been a specialty of Mr. Truex for several years, he having first equipped six cars of the New York and Chicago line over the Pennsylvania Railroad, which was the first train lighted by electricity.

The Engineering Equipment Company, of New York City, has become agent for the well-known Habirshaw wires, cables and cores. The Habirshaw flameproof wire is attracting considerable attention, especially as the new underwriter rules require its use. Now that the India Rubber and Gutta Percha Insulating Company, which manufactures exclusively the Habirshaw wires, has secured a new and fine factory at Yonkers, N. Y., the output of this wire will be increased materially by the facilities afforded by the new works. The Engineering Equipment Company will be, from about May 1st, in the Central Building, No. 143 Liberty street, New York, but the stockroom for Habirshaw wire and Underwood belts will be continued at No. 73 Cortlandt street, which has been the temporary office of this new company.

The B. F. Sturtevant Company, of Boston, has had a large increase in business during 1890, and its Chicago branch has removed to new and much larger quarters at 16 South Canal street, Chicago, Ill., where an entire new building furnishes ample accommodations for the large stock of steam engines, blowers, exhausters, heating and ventilating apparatus and portable forges. This branch will remain under the energetic control of Messrs. Foss & Noble, and will form the headquarters for the trade of the Middle and Western States. The Western house stock will be greatly increased, in order to provide for immediate shipment in all cases, and a corps of experienced engineers will be maintained for estimating upon and installing plants for heating, drying, ventilating, etc.

The National Telephone Manufacturing Company, of Boston, has been patiently at work during the past few months improving its telephones, besides selling its service for short distance lines. Probably the largest acoustic telephone installation ever done in the country has just been completed by this company. This installation comprises 12 telephones, or stations, in the immense factory of the Portsmouth Shoe Company, at Portsmouth, N. H., connecting directly with the office all of the different floors and departments. The building is nearly 400 feet long and six stories high. The service enables the superintendent to communicate with every floor without disturbing any but the station signalled. In one room 300 sewing machines are operated, but no disturbance is caused to the "National" diaphragm, which speaks strongly of its excellence.

A New Primary Battery.—Mr. B. J. Wheelock exhibits at No. 18 East 18th street, New York City, a primary battery for which very high claims are made. The size of the usual cell for working small motors, for sewing-machines, ventilators, and similar work, is as follows: 3¾ × 10 × 9 inches. The elements used are zinc and carbon, and an E. M. F. of two volts is obtained. On short current the cell gives 35 to 40 ampères. Depolarization is very inexpensively effected. A new feature is that this battery can be recharged while at work, in both inner and outer jars. At the exhibition referred to, a sewing-machine is shown at work operated by both C. & C. and Perret motors with two cells of the above size contained in a case 8 × 13 inches, which for both speed and strength is all that can be desired. The inventor states that recently an improvement was made which has reduced the internal resistance and increased the constancy of the battery so that the efficiency is almost doubled.

The Aluminium Carbon Company has purchased ground at Lancaster, N. Y., 10 miles from Buffalo, and has almost completed a factory 60 × 170 feet for the manufacture of arc light carbons and carbon plates for batteries. The capacity of the works will be 40,000 carbons a day at the start, which is expected to be before June 1. The machinery is now at hand and at least 60 men will be employed at the opening. The capital stock is $40,000, fully paid up. The officers are as follows: President, Andrew Cant; vice-president, R. J. Getz; secretary and treasurer, F. V. Doty, and superintendent, W. H. Boulton. The main offices of the company will be in the Coal and Iron Exchange building, Buffalo, N. Y. Mr. W. H. Boulton, who is superintendent of this company, needs no introduction to users of carbons; he is well known as an expert—one of the best. Mr. F. V. Doty, who will be general manager, is a well known railroad man, for the last few years passenger agent for the Chicago, St. Paul & Kansas City Railroad, with headquarters at Buffalo. Mr. Doty's large acquaintance in the railroad field will materially aid him and his company in his new venture.

The Electrical Supply Trade.—One point of view from which to note the rapid growth of the electrical business is quickly obtained in visiting the warehouses of the supply trade in Chicago, where there are said to be more general electrical supplies stored than in any other city in the world. Three years ago $10,000 was considered ample capital for the supply business; to-day $200,000 is little enough. Then, a shipment of a carload of wire was heralded across the continent; now, it is of almost daily occurrence, and an entire train loaded with electrical supplies would excite little or no comment. Especially notable for the extensive stock actually carried on hand is the well-known establishment of the Great Western Electrical Supply Company, 190, 192 Fifth avenue, where the five double floors and basement are well filled with new, practical and useful articles required in the various electrical fields, and where the central station manager can quickly select everything required in station or line construction, and the amateur purchase his bits of carbon and zinc; where owner, architect and consulting electrician can meet and select one or a thousand electric fixtures that will harmonize with the interior decorations of palace or office, and where the contractor, on closing arrangements for the rapid construction of electric railway or lighting stations within a limited period, can send his order for the necessary material and rely not only on immediate shipment of the exact goods ordered without the substitution of undesirable articles, but can also rely on the prices charged being in every respect fair and just, whether previous quotations have been given or not. While as direct importers and exporters, as well as extensive manufacturers, they are able to sell at manufacturers' prices and thus save to the consumer the middleman's profit. To further facilitate shipments they are arranging for the equipment of a factory on Fifth avenue, where, under one roof, they can rapidly turn out the requisite quantity of their well-known type of incandescent lamps and also construct their special arc lamp designed for any arc system, and their arc lamp for incandescent systems, as well as their many other specialties. When these arrangements are completed this proposed factory will form quite a little industry, giving employment to nearly 100 persons. The officers of the company are well-known business men. Mr. E. R. Gilman, formerly of the United States Army, is president, while Mr. H. K. Gilman, formerly of the United States Navy, has had the general management of the company since January last, and much of the excellent credit the house has won is due to his conservative methods. Mr. T. C. Turlay, formerly of Leavenworth, Kan., is the treasurer and general credit man.

Business Notice.

Battery Cut-Out, Cheap.—Sensitive, reliable, never requires attention. Gas lighting much improved by its use. Electric Supply Company, of 105 South Warren street, Syracuse, N. Y.

OUR ILLUSTRATED RECORD OF ELECTRICAL PATENTS.

U. S. PATENT ISSUED MAR. 17, 1891.

448,598. Electric Transportation System; Schuyler S. Wheeler and Charles S. Bradley, of New York, Assignors to said Wheeler, Trustee. Application filed July 29, 1889. An electric transportation system comprising a movable vehicle or car carrying a magnetic mass, and a guide way for said car, and an inductor along the guideway, the mass and inductor being continuously in inductive relation and connection with a source of energy for propagating along the guideway a succession of polar waves whereby a movement of translation will be imparted to the car by the successive waves.

U. S. PATENTS ISSUED APRIL 14, 1891.

450,153. Trolley for Electric Railways; Arthur S. Hickley, of Richmond, Assignor of one-half to John C. Shaffer, of Indianapolis, Ind. Application filed April 14, 1890. The combination of a trolley arm, a head thereto, having bearings for the trolley wheel, said head being socketed to receive the upper end of said arm, and said arm resting and secured in said socket with sufficient strength to resist the ordinary strain thereon and capable of being removed therefrom by any unusual strain coming thereon.

450,159. Multiple-Fuse Cut-Out; Arthur W. Jones, of Boston, Mass., Assignor to the Thomson-Houston Electric Co., of Conn. Application filed Dec. 6, 1890. A safety-fuse apparatus comprising a pair of fixed contacts, a fuse-carrier having movable contacts co-operating with said fixed contacts and provided with a manual operating device, and a continuous strip or wire of fusible material engaged in sections by said movable contacts, so as to bring successive portions of said wire into connection with said fixed contacts.

450,163. Non-Sparkling Clamp for Trolley-Wires; Chas. A. Lieb, of New York. Application filed Nov. 28, 1890. In an electric railway system the combination of a holder for trolley-wires, a flexible current conveying device adjacent to the said holder and in electrical connection with the wire, and a trolley or contact which moves with the car in contact with the trolley-wire.

450,164. Electric Railway-Wire Support; Chas. A. Lieb, of New York. Application filed Dec. 10, 1890. In an electric system, a strain equalizer, comprising, essentially, parts which move upon each other, and a spring placed between them, and means whereby the ends of the wire may be attached to them respectively.

450,172. Electric Switch for Electric Railways; Frank Mansfield, of New York. Application filed Nov. 18, 1890. In an electric switch the combination with a swinging operating lever and a switch-box or plate moving in fixed relation therewith, of contacts arranged upon said box or plate eccentrically to the centre of movement of the operating lever, whereby the movement of said lever in one direction may serve to close the contacts and the movement thereof in the opposite direction may serve to open the contacts.

450,173. Electric Switch for Electric Railways; Frank Mansfield, of New York. Application filed Nov. 18, 1890. In an electric switch the combination, with a swinging lever for operating the switch, of a switch-box or plate moving in fixed relation with said lever and provided with a fixed terminal, a pivoted contact-arm mounted upon the said switch-plate eccentrically to the centre of the movement of the same and adapted to engage the said terminal when moved to one limit of its movement, connections intermediate the said switch-plate or box, and the said pivoted contact-arm for moving the latter upon its pivot as the switch-plate or box is rotated.

450,182. Light-Signal System; Bernice J. Noyes, of Boston, and Howard F. Eaton, of Cambridge, Mass. Application filed April 5, 1889. In a light signal system an electric circuit including a central station and several light signal stations, each light signal station containing a light signal and magnet for effecting its operation, also a normally wound return signal transmitter and magnet for releasing it, and also an individual call switch for rendering operative both of said magnets, and the central station containing a circuit controller for the individual call-switches, and a return signal receiver and a circuit controlling device for the light signal operating magnets.

450,184. Trolley Device; Alexander Palmros, of Lynn, Assignor of one-half to Victor E. Peterson, of Boston, Mass. Application filed Jan. 8, 1891. A trolley device, consisting of a trolley wheel having its bearing spindle loosely journaled in a bearing on the trolley pole, and a pair of opposing coiled springs surrounding said spindle and secured to it and the trolley pole or its bearing.

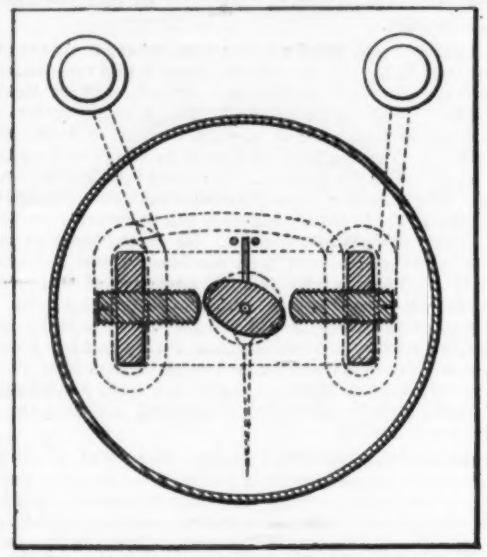
450,193. Rail Connection with Supplemental Wire; Chas. A. Robinson, of La Grange, Ill., Assignor to George Cutter, of same place. Application filed Sept. 22, 1890. The combination in an electric railway system of the rails, a parallel copper rod connecting the sections of the same, a supplemental return-cir-

cuit wire running longitudinally between the rails, and a copper strap connecting said rod and supplemental wire.

450,206. Mechanism for Carrying Wires Through Conduits; Ferdinand A. Wessel, of Brooklyn, N. Y, assignor of one-half to August Giese, of same place. Application filed Sept. 24, 1890. A wire-threading device, consisting of a shank with a self-clamping carriage rigidly fastened thereto, and another clamping carriage which runs on said shank, and a contracting spring or springs for drawing the carriages toward each other.

450,219. Dynamo-Electric Machine; William Forman Collins, of New York, assignor to the Waddell-Entz Electric Company, of same place. Application filed Feb 18, 1890. The invention consists of a field-magnet structure which is confined entirely inside of a Gramme ring armature. This structure consists of a single coil or spool, the spool-pieces of which are extended radially across the head of the spool, and then again extended to form the working-poles which stand parallel to the axis of and embracing the spool. If the machine is multipolar, viz.: if there is more than one pole-piece connected with each end of the magnet-core, then the working-poles will alternate with one another around the spool, thus forming a kind of cage within which the spool is confined. (See illustration.)

450,221. Instrument for Measuring Electric Currents; Henry Hardinge Cunynghame, Frederick Lawrence Rawson, and Otway Edward Woodhouse, of London, England. Application filed April 1, 1887. This device consists essentially of an electromagnet having oppositely arranged horizontally adjust-



No. 450,221.—Instrument for Measuring Electric Currents.

able polar extensions, between which and mounted upon a vertical axis is a soft-iron armature shaped as an ellipse, connected to a torsion-spring and carrying an index. (See illustration).

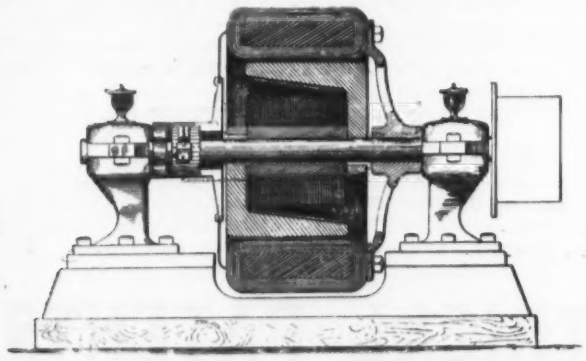
450,228. Printing Telegraph; Pliny H. Fisk, of New Richmond, Minn. Application filed Oct. 17, 1890. This invention consists in a series of levers pivotsd above the key-board of each of the typewriters composing the series,a series of hammers connecting the levers and suspended above each key of each of the typewriters, a series of transmitting keys upon each of the series of typewriters and means for electrically operating the levers, and thus striking the typewriters.

450,239. Non-Interference Signal Box; Wm. H. Kirnan, of Brooklyn, Assignor to the Gamewell Fire-Alarm Telegraph Company, of New York, N. Y. Application filed Aug. 18, 1890. The invention consists in a device for maintaining the circuit in its most efficient condition, by cutting out the magnets, circuit controlling springs, etc., of all the idle boxes, and closing the circuit through or around such boxes by a circuit of low resistance while they are out of use, and in means for locking the switch by which the circuit is changed, whereby when a signal is started the switch cannot be moved by the hand or by shutting the box door to re-establish a low-resistance circuit and put the apparatus in its normal condition or condition of rest until the signal is completed.

450,242. Trolley-Wire Support; Chas. A Lieb,of New York. Application filed November 14, 1890. A support for an electric wire, comprising, essentially, a cross-bolt, a threaded metallic piece through which the cross-bolt passes, and insulating material between them.

450,245. Fire Alarm and Telephone System; Samuel W. Ludlow, of Madisonville, O. Application filed July 12, 1890. A telephone apparatus, consisting of a generator, transmitter and battery, and means for automatically operating said generator upon an outbreak of fire, and mechanism for raising the switching-lever, so that the telephone-transmitter may be switched into the line wire to convey a sound agreed upon as an alarm audibly to the operator at the telephone exchange.

450,260. Thermostat; William F. Singer, of Carthage, assignor of one-half to Gilbert L Haviland, of Syracuse, N. Y.



No. 450,219.—Dynamo Electric Machine.

Application filed July 29, 1890. A thermostat having contact-points carried by spring-arms, two independent bottoms, each bottom being held normally in position by fusible plugs, and supports between the respective bottoms and the spring-arms carrying the contact-points, whereby an electric current will be broken, and afterward restored by the displacement of the respective bottoms occasioned by the fusing of the plugs

450,272. Telegraph Relay; Robert O. Wicks, of Troy, N. Y. Application filed Dec. 8, 1890. A telegraph relay consisting of a magnet whose yoke is provided with a screw, a pinion provided with an internal screw thread rotary upon said screw, a gear wheel, engaging with said pinion, means, such as a handle, for turning said wheel, a helical spring surrounding said screw and supporting said magnet, an armature for the magnet carried by a pivoted lever, which is provided with electric contact normally in open circuit with a local battery, the said magnet being in circuit with a distant battery, a retractile spring holding said armature away from said magnet, a spindle provided with a set screw and connected with an insulating thread, which terminates said last named spring, and an indicating finger mounted upon said handle.

450,285. Galvanic Battery; Walter Ambus Crowdus, of Memphis, Tenn., Assignor to Jo. W. Allison, Trustee, of same place. Application filed Oct. 8, 1890. The combination, with a battery-cell having a metallic trough in its bottom, of a conductor leading from said trough, and an electrode with its bottom portion immersed in the mercury, whereby the mercury forms an electric connection between the electrode and the metallic trough.

450,292. Circuit Closer; William C. Johnston, Jr., of Lynn, Mass. Application filed Dec. 17, 1888. This invention consists in the combination, in an electric circuit, of two contact surfaces or terminals arranged so as to be brought together and separated by a movement which causes the contact-surfaces to slide over each other, whereby foreign matter and corroding particles are removed and the contact surfaces kept polished.

450,294. Insulator; Chas. A. Lieb, of New York, and Erwin Lavens, of Brooklyn, N. Y.; said Lavens assignor to said Lieb. Application filed Dec. 8, 1890. The invention consists in a metallic casting provided with a recess in which the insulating material may be placed, and having also hooks or their equivalents whereby the supporter may be attached to a sustaining-wire, and it has also a cross-bolt or pin whereby the eye-bolt or its equivalent and also its insulating material may be permanently held within the metallic part or casting.

450,304. Art of Making Filaments for Electric Lighting; Silvanus Van Choate, of Boston, Mass. Application filed May 31, 1890. A filament or base built up and composed of aluminum and iodine.

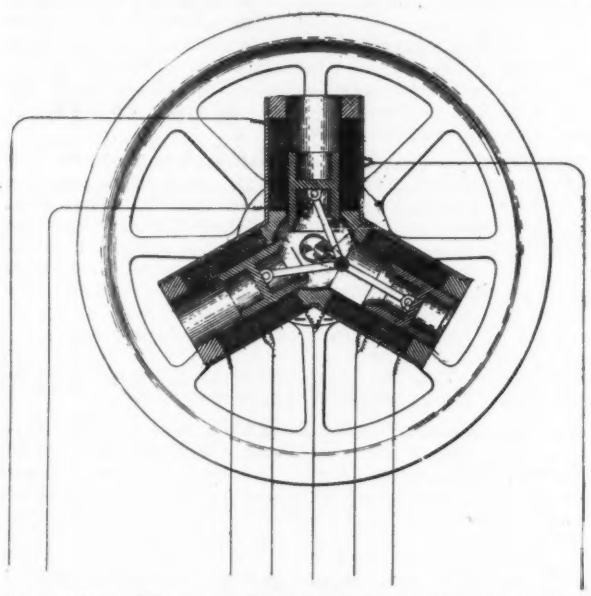
450,319. Rheotome; George Edward Pragnell, of Brooklyn, N. Y. Application filed April 12, 1890. The combination with a rheotome or interrupter of an electromagnet, an armature therefor, a strip of spring material on said armature, but insulated therefrom an electric circuit, and a lever contacting with the strip of spring material of the armature at one end and having an adjustable screw at the other end contacting with the metal of which the armature is formed.

450,354. Porous Cell for Galvanic Batteries; William Burnley, of North East, Pa. Application filed Oct. 21, 1890. The combination in a porous cup for galvanic batteries of a shell of pasteboard or wood veneer bent into a cup shape and having the upper end thereof saturated with paraffine wax, cords or other suitable fastenings for holding the edges of said shell together, and a seal or bottom secured in the lower end of said shell and small holes through the sides of said shell.

450,358. Auxiliary Mouthpiece for Telephones; William N. Marcus, of Philadelphia, Pa. Application filed Feb. 10, 1891. In an auxiliary mouthpiece for telephones, a socket-plate and clamps for attaching the same to a telephone box, a rigid bent tube passing through said socket-plate and capable of rotation therein, having a collar rigidly fixed thereon, the socket plate being arranged to press against the collar to secure frictional bearing for the tube.

450,359. Receiving Telephone Support. William N. Marcus, of Philadelphia, Pa. Application filed Feb. 10, 1891. The invention consists in an adjustable bracket, which bracket may be placed on the wall of the room in which the telephone is placed, to dispense with the necessity of holding the receiver in hand.

450,367. Insulation of Armatures for Dynamo-Electric Machines; Rudolf Eickmeyer, of Yonkers, N. Y. Application filed Aug. 28, 1890. An armature drum or core for dynamo electric machines clothed on its face with an inner layer of narrow



No. 450,542.—Reciprocating Electric Railway Motor System.

insulating material laid diagonally from end to end, and an outer layer of similar material laid diagonally but reversely to the inner layer.

450,384. Electric Wire Insulator; Daniel A. Bertolette, of Norristown, Pa. Application filed Dec. 12, 1890. An electric wire insulator consisting of a body, grooves at either end of said body, and outwardly, downwardly and enwardly inclined lips adapted to protect a section of the body between said grooves from becoming wet.

450,390. Electric Time Call; Richard Varley, Jr., of Englewood, N. J. Application filed Nov. 18, 1890. The combination with a clock movement and an alarm, of a revolving circuit-closing arm, contact pins for the same, an annunciator board and check holders adapted to receive several checks, and connected respectively with the contact pins and circuit wires, and a portable circuit-closing check adapted to be received by the check holder and to close the metallic circuit, so that the alarm is rung when the moving arm of the clock comes in contact with the pin at the designated hour.

450,425. Heat Annunciator; Adoph Reinemann, of New York. Application filed May 31, 1890. The invention consists of a yielding vessel containing two or more chemicals or substances that are separated by a readily fusible partition. When the partition melts down, the chemicals or substances react or combine, and evolve gases that expand the yielding vessel. The vessel in expanding makes a suitable mechanical or electrical contact that sets off the alarm. (See illustration.)

450,426. Electrical Apparatus for Reproducing Sounds; Jules Ernest Roulez, of Paris, France. Application filed Oct. 9, 1890. A microphonic or other similar electric apparatus with a membrane or diaphragm of semi-conducting material, having one terminal conductor connected to it, in combination with one or more insulated blocks, to which the other conductor is connected, these blocks being also of semi-conducting material and secured to and supported solely by the said membrane.

450,441. Automatic Switch for Electric Motors; Fenner E. Whipple, of Philadelphia, Pa., Assignor to Thos. H. Dallett and George A. Dallett, both of Cheyney, Pa. Application filed Oct. 13, 1890. The combination in an electrical switch of a pair of sheaves and a belt passing around the same, and a switch-closing plate carried by said belt.

450,458. Electric Signal; Robert H. Gruchow, of Chicago, Ill. Application filed Nov. 21, 1890. In an electric signal, a push button, consisting of a button provided with a projection, a connecting strip and contacts, and a case provided with the flexible metallic strips connected by wire conductors with the battery.

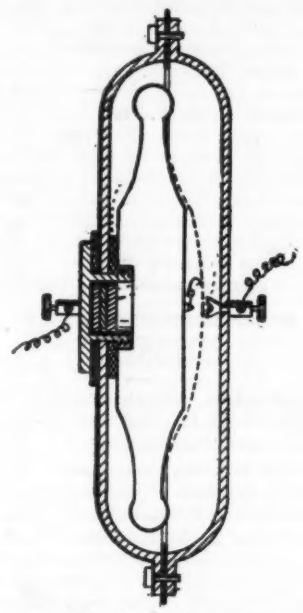
450,466. Fire Alarm and Telephone System; Samuel W. Ludlow, of Madisonville, O. Application filed Oct. 25, 1890. In a combined fire-alarm and telephone system, the combination, with the telephone-line wire and telephone apparatus and electrical means for sending a call to the exchange independent of the telephone instruments, of electrical circuits from the primary and secondary coils of the subscriber's transmitter independent of the ordinary telephone circuits of the telephone apparatus, switches to close said circuits, and means for operating them automatically after a call has been sent, so that the telephone-transmitter may be placed in circuit independent of the telephone circuits of the ordinary telephone apparatus to convey a sound to the exchange.

450,489. Trolley Guide; William E. Jackson, Jr., of Augusta Ga. Application filed Nov. 14, 1890. The combination, with the trolley pole and wheel, of a guide or finder pivoted to the pole below the wheel and provided with an armature, an electromagnet on the upper end of the pole and normally holding the guide or finder depressed, and means for throwing the guide or finder upward upon the release of the armature.

450,541. System of Electrical Distribution; Chas. J. Van Depoele, of Lynn, Mass. Application filed Sept. 19, 1890. In a system of electrical distribution, a chemical counter-electromotive force device between the leads of a supply circuit, a commutator to the segments, of which the elements of the device are connected, a working circuit in connection with the commutator, a stationary brush or brushes bearing upon the commutator, and means for changing the relative position to the elements of said device of the statiouary brush or brushes, whereby the potential of the current supplied to the working circuits will be varied.

450,542. Reciprocating Electric-Railway Motor System; Chas. J. Van Depoele, of Lynn, Mass. Application filed Sept. 19, 1890. In a reciprocating electric-railway motor system, the combination with the vehicle to be driven, of a source of defined rising and falling current moving therewith, a reciprocating motor concentric with the axle thereof and having a plurality of motor-coils, each provided with a movable magnetic piston directly connected thereto, and means for supplyinng the defined currents to the motor coils in succession. (See illustration.)

450,513. Electro-Magnetic Reciprocating Engine; Chas. J. Van Depoele, of Lynn, Mass. Application filed Dec. 29, 1890. An electro-magnetic reciprocating engine comprising a magnetic shield or envelope, motor-coils within the envelope, a



No. 450,425.—Heat Annunciator.

magnetic piston adapted to be reciprocated within the motor coils and magnetic extensions from the envelope towards the interior of the coils.

450,544. Pulsating Current Electric Motor; Chas. J. Van Depoele, of Lynn, Mass. Application filed May 26, 1890. The combination, with a source of continuous and pulsating currents, of a motor having a closed circuited armature encompassed by an inducing-coil in circuit with the source of pulsating current and field-magnets of constant polarity reacting upon the poles induced in the armature.

450,551. Electric Switch; Frederick Adam and John Knapik, of St. Louis, Mo., Assignors to Blattner & Adam, of same place. Application filed Nov. 13, 1890. This invention comprises an electric switch, the case of which is about flush with the walls. It is arranged to be held in position by the same spring, the spring acting to prevent its remaining in any intermediate position.

450,552. Armature; La Motte C. Atwood, of St. Louis, Mo., Assignor to the Atwood Electric Co., of same place. Application filed Oct. 28, 1890. The combination with a shaft, of independent hubs fitted thereon and having arms or spokes, a wrapped ring encircling the shaft between the spokes of said hubs and having projections, a removable cylinder fitted snugly over the wrapped ring and being revoluble with the shaft, screws securing said cylinder to said projections, and screws passing through said cylinder into said spokes.

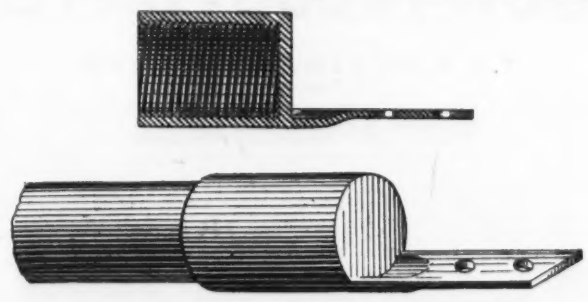
450,558. Electric Call-Bell and Indicator; William Cox, of Toronto, Canada. Application filed April 11, 1890. This invention consists of latch levers pivoted on a frame and operated by pull-wires, with indicator drops arranged on a spindle.

450,577. Regulator for Electro-Therapeutic Apparatus; John H. Davis, of Findlay, O., assignor of one-third to Yeaman Bickham, of same place. Application filed May 12, 1890. The combination, with a battery, of cylindrical tubular handles, perforated for about half their lengths from their open ends, and covered for the remainder of their lengths with insulating material, and pieces of sponge fitting in the perforated portions of said cylinders.

450,581. Electric-Wire Connection; Edward J. Gatley, of Rome, N. Y., Assignor to Edward Walworth, of same place. Application filed Feb. 7, 1891. The combination with an arc electric lamp movable up and down, a stationary wire, a movable wire, and an insulator for supporting the stationary wire, of a metallic connection division, having a socket at one end for receiving the stationary wire, a clamp upon said connection division for engaging the insulator, a second metallic connection division hinged at one extremity to the former, and a socket at the opposite end of the latter connection division for receiving the movable wire.

450,586. Electric Railway; Rudolph M. Hunter, of Philadelphia, Pa., Assignor by mesne assignments to the Thomson, Houston Electric Company, of Boston, Mass. Application filed June 4, 1889. In a branching electric railway, a main-line conductor and a branch-line conductor extending along the main line and branch tracks respectively, in combination with two generators, one connected to the main-line conductor and the other connected to the branch-line conductor.

450,587. Electric Wire Supporter; Chas. A. Lieb, of New York, and Erwin Lavens, of Brooklyn, N. Y., said Lavens assignor to said Lieb. Application filed Dec. 8, 1890. An insulated supporter for electric wires, comprising a hollow open-sided metallic



No. 450,589.—Holder for Electric Cables.

casing, a threaded nut therein, and insulating material surrounding the nut.

450,589. Holder for Electric Cables; Joseph W. Marsh, of Pittsburgh, Pa., Assignor to the Standard Underground Cable Company, of same place. Application filed Sept. 12, 1890. The combination, with a canle, of clips secured to the ends of the cable and adapted to be attached to the spool for the transportation of the cable. (See illustration.)

Copies of the specifications and drawings complete of any patent mentioned in this record—or of any other patent issued since 1886—can be had for 25 cents. Give date and number of patent desired, and address The W. J. Johnston Co., Ltd., Times Building, N. Y.